This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

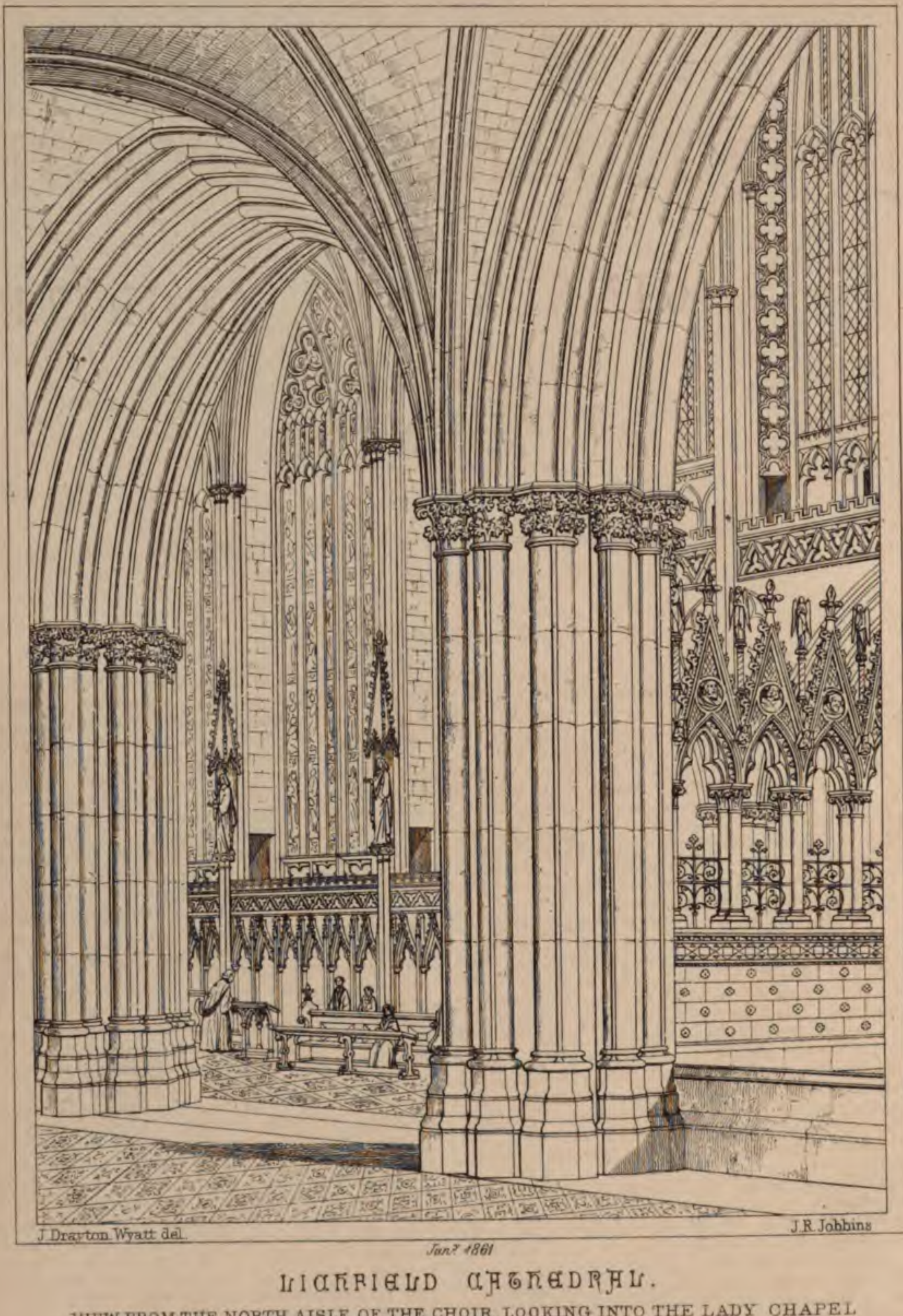
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

NYPL RESEARCH LIBRARIES
3 3433 06275620 4

1.



Jan.ʸ 1861

LICHFIELD CATHEDRAL.

VIEW FROM THE NORTH AISLE OF THE CHOIR, LOOKING INTO THE LADY CHAPEL

G. G. SCOTT, R.A. ARCH.ᵀ LONDON.

THE

CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

VOLUME TWENTY-FOURTH.—1861.

LONDON:
W. KENT AND CO., 23, PATERNOSTER ROW.

PRINTED BY W. KNOTT,
GREVILLE STREET, HATTON GARDEN, E.C.

THE
CIVIL ENGINEER AND ARCHITECT'S
JOURNAL.

THE STATICS OF BRIDGES.

THE theoretical and practical knowledge of the construction of bridges occupies a very important department of the wide and varied field of engineering science. As a special study, it is characterised no less by the extent and diversity of its subject than by the abstruse and occasionally complex nature of the investigations to which it has given rise. The different circumstances of site, of approaches, span, and headway; the facilities for abutments, piers, or moorings; the nature of the foundations, and the peculiar difficulties frequently encountered in preparing these, as well as in erecting the superstructure; the stipulations often exacted for the convenience of navigation; the precautions demanded to meet external stress of wind or water, as well as the due provision for carrying both dead and moving loads, and the allowance for effects of settlement or of changing temperature; the distinct types of superstructure, known as the arch, chain, and girder, and the numerous forms of simple or combined application in which they are found, are some of the considerations that must enter into any thorough and complete inquiry. And these conditions are not only different for each bridge, but in many cases assume so special an aspect that it appears desirable for any great bridge to have a history of its own, recording not only all the details of form and construction of the finished work, with the settlement observed on the application of a given test load, but also the successive difficulties that had to be overcome from commencement to completion, and the various expedients devised to meet them, whether successful or otherwise.

A theoretical inquiry, simply into the stability of different forms of superstructure, reduces itself within far narrower limits. Such an inquiry, proceeding on abstract reasoning, seeks to elicit general results, and to arrange them so as to admit of their ready application to individual cases. But even in this comparatively restricted range of investigation we are confronted at the outset by three distinct principles of construction, each of which demands, or at least has always had accorded to it, a distinct method of examination. Between the theories of the arch and the girder there exists a sufficiently wide difference; and although a very close affinity is recognised between the curve of equilibrium of the chain and the line of pressure in the arch, the relations considered to subsist between the latter line and those known as intrados and extrados, and the commonly received view as to points of rupture, are peculiarities to which we find nothing analogous in the laws of catenaries. But when we pursue our research into those cases where the arch and girder, or the chain and girder, are combined; or where the equilibrium of a loaded rib results partly from an external reaction and partly from its inherent transverse strength; and when we seek a solution of such complex cases by applying two methods of investigation which have very little in common to the component parts of a single structure, difficulties present themselves which at first sight seem insuperable. But it will be found, on looking into the matter with care and attention, that the only formidable difficulty results (as so frequently happens) from what we have taken for granted without question or examination. In the arch, as in the girder, the principle of the lever forms the very basis on which all the remaining rests. But while *every portion* of the load on the girder is considered to be divided between the two supports (in the inverse ratio to its distance from either), the load on the arch is regarded as separating at the crown into two parts, each carried *exclusively* by the nearest abutment. If, then, we assume that it is necessary to treat the load one way for the arch, and the other way for the girder, great perplexity besets the examination of any bridge in which a combination of these two principles is presented, in the absence of any *primâ facie* reason for determining what portion of the load should be regarded as carried by an arch, and what portion as carried by a girder. But if we can satisfy ourselves that the entire load on the girder, no less than that on the arch, actually divides itself into two sections at a certain assignable point, either section throwing all its weight on the nearest support, the threatened difficulty will at once vanish. It might have been thought obvious, had the question ever been distinctly asked, that reasonings based on the same fundamental law (that of leverage), however variously conducted, must inevitably reach identical results, and that the calculated strains at every point of a girder would be the same, whether they were arrived at in the ordinary way or considered as resulting from the action of two sections of load, each ponderating to its nearest pier only. It will be endeavoured, in a future paper, to show that such is actually the case, and to exhibit a method of treating the load and calculating the moments at different points equally applicable to arch, chain, and girder, and, it is believed, more simple than the generally received rules, obviating the necessity of either finding a series of centres of gravity (as in the arch), or dividing every component portion of the load according to its distances from the piers (as in the girder). The point where the load divides itself is sufficiently evident in a masonry arch; in a chain it is equally obvious on inspection, and also capable of being found by calculation; in a girder it is not detected by the eye, but will always coincide with the point of greatest strain; and where the girder is not continuous, its determination is a sufficiently easy matter.

It is, therefore, proposed to bestow some consideration on those statical principles which all bridges, irrespective of form or circumstance, possess in common; to examine the effect of the ponderating load in what it is hoped may prove to be the simplest and the most general way; and, perhaps, after such inquiry into the action of the load, occasion may be found to examine the special modes of reaction by virtue of which the equilibrium of each description of bridge is maintained.

The arch was made the subject of elegant and laborious mathematical investigation long before the exigencies of railway construction led to an exact appreciation of the elastic forces of materials. Proceeding upon the general understanding that masonry was capable of supporting heavy thrusts without noticeable compression, but possessed of very small cohesive power, the theorist found it convenient to assume that the arch was composed of voussoirs absolutely imcompressible, and not cemented at the joints. To simplify investigation, the pressure distributed over the area of each joint was imagined to be concentrated into a resultant acting at a single point, and the line which, passing through the voussoirs, connected these points of resultant pressure, was called the line of pressure, and was found to possess properties identical with those of catenaries (using this term in its most general sense). But although the conditions of any assigned line of pressure were found capable of exact determination, uncertainty attended the application of this admirable theory to the arch, owing to the circumstance that an indefinite number of lines of pressure, all equally adapted to the given load, could be inscribed within the limits of the voussoirs. At the same time it was seen that if any two points in the semi-arch were given as points in the line of pressure, the line itself could be fixed; so that the problem ultimately resolved itself into that of finding the actual position of two of the resultant points.

Many have thought it proper or convenient to assume that the resultant thrust passes through the centres of the keystone and skewback. This would seem at first sight the most natural idea; but if we suppose the material of the arch incompressible, it becomes by no means clear how the reaction causing the thrust can be generated, if the line of pressure be thus situated. Yet, on the kindred hypothesis of a parallelism between intrados and the line of pressure, general deductions have been made as to the distribution of loading proper to any given form of arch—deductions interesting to the mathematician, but hardly of much practical value to the engineer, who aims at adapting the bridge to the load, rather than the load to the bridge.

It has however been generally considered more correct to select as the actual line of pressure that which touches intrados at or near the springing, and rises thence to touch extrados at or near the crown. Were the voussiors really incompressible, and the joints uncemented, this law would be absolutely correct; it is an inevitable conclusion from the fictitious data. In reality it is much closer to the truth than the supposition that the thrust passes through the centre of the keystone and that of the skewback; and it is sufficiently accurate for general application to arches of stone or brickwork. The application has however been found hitherto to involve much labour and difficulty; in many cases a complicated tentative process has to be repeated twice or oftener in order to get approximately at the points of contact with extrados, known as points of rupture.

In order accurately to exhibit the generation of the reacting force, it would indeed be necessary to consider the elastic properties of the material employed, and to inquire into the condition of a voussoir when the resultant thrust does not pass through its neutral axis. In dealing with masonry such nice discrimination might be rather curious than useful. But when continuous iron ribs come under examination, it is essential to bear in mind that the theory of disconnected voussoirs incapable of being compressed, and the determination of the actual line of pressure by means of points of rupture, are no longer admissible.

The origination and rapid extension of railways, marking an era within the scope of living memory, yet already more fruitful in changes than many preceding centuries, first brought into frequent use a class of bridges which, if not new in the principle employed, were virtually so in its scientific and skilful application. These iron-ways, constructed in a country already intersected with roadways and canals, necessarily crossing the streets of populous towns, and occasionally having to be carried over navigable rivers, or even arms of the sea—conveying a traffic which public safety required to be kept distinct, while convenience demanded its being often brought close to large thoroughfares, and which only admitted of very flat gradients—frequently present conditions as to headway, span, or mechanical adjustment, only to be satisfied by girder bridges. Under a moving load, producing strains of unexampled severity, distances were spanned which had been previously unattempted. The employment of iron then became indispensable, and the necessity of avoiding useless weight in the girder itself, no less than the consideration of cost, led to thorough investigation of the best way of distributing the material, whether cast or wrought, and of the strains to which it could be safely subjected. The sensation produced by the failure of the Dee Bridge subsided into a conviction of the insecurity of cast-iron girders for large spans, and stimulated the more general construction of girders in wrought-iron, a material in which gigantic proportions were ultimately obtained. The happy boldness which confronted the task of throwing a tube across the Menai was united with the prudence and wise precaution which dictated the series of preliminary experiments bearing on the strength of wrought-iron cellular beams; and thus, assisted by able mathematical research, has left results on record invaluable to science.

Thus while the theories of the arch and of the catenary have remained stationary, or nearly so, the investigation of the girder has advanced with rapid strides, and has gone hand in hand with a precise and intimate knowledge of the nature of the materials of construction, and the connection between definite change of form and definite reaction, not brought to the earlier studies of the arch and chain.

It will be endeavoured, when continuing this subject, to exhibit the action of the load, and the task which it imposes on bridges generally and irrespective of their mode of construction, as to make some approach to a truly comprehensive theory; and perhaps also to apply to the earlier branch of the science the practical results which have proved so useful in the more thorough elucidation of the girder.

ON ACOUSTICS.*

By T. Roger Smith, Architect.

The subject to which I venture to invite your attention is that of acoustics, or the science of sound; in reference of course to its bearing on the arrangement and construction of those buildings where the free transmission of sound is of importance.

It will not, I think, be deemed necessary that I should advance any apology for the subject itself. The proper construction of buildings intended for music or public speaking is a point of vital interest to every architect, as under this category may be comprehended all the more important works that come into our hands; and such buildings—however excellent in other respects—cannot certainly be said to have fulfilled the design with which they were erected, unless they have been made favourable to the easy transmission of sound. A knowledge of the laws that regulate this transmission, and of the methods necessary to bring a building into conformity with those laws, is then most desirable to us.

A very considerable time has elapsed since a paper on this subject was read before the Institute; and this consideration, coupled with the fact that even such books as exist on the subject are not generally known, induces me to hope that it may be possible to lay before you some already-ascertained facts of interest, but which are not so familiar as they deserve to be.

I must disclaim however the ability to present anything new in any other sense than the one just indicated. The subject has always occupied a share of my attention as a reader, but not as an experimental philosopher; and latterly it has become my duty to search very thoroughly for all accessible information that relates to it. And it has been the difficulty of collecting scattered facts, and of obtaining even the titles of books, that has principally made me feel that an account of the books and other sources of information accessible, and a condensed exposition of the most important points to be gleaned from them, might be of use to others.

---

* From a paper read at the Royal Institute of British Architects.

I.

In the commencement of an inquiry into the laws governing the distribution of sound in buildings a student would naturally seek information on the nature of sound and the laws of acoustics, from treatises on physical science. The works best worth consulting are the following, and I name them now to avoid interrupting the main subject afterwards:—The treatise on Sound, by Sir John Herschel, published in the 'Encyclopædia Metropolitana,' and since issued separately. This is the best work on the subject in English; but it has the drawback that it does not contain any account of the discoveries of the last thirty years, having been published in 1830. Mrs. Somerville's 'Connection of the Physical Sciences.' Detached papers by Prof. Wheatstone. The article on Acoustics in the 'Encyclopædia Metropolitana.' Arnott's 'Elements of Physics.' Brewer 'On Sound.' 'Cours de Physique' of Mons. Biot. 'Cours de Physique" of Mons. Pouillet. 'Traité d'Acoustique,' by Chladni; a standard work; also published in German. And the writings of Savart and Biot and others, published in the 'Annales de Physique et de Chimie,' and the lectures of Savart reported in 'l'Insitut.' On the special subject of building we have published in England,—Saunders 'On Theatres.' Wyatt 'On Theatres,' quoted in 'Gwilt's Encyclopædia.' 'Inman's abstract of evidence connected with the building of the Houses of Parliament.' A considerable number of papers scattered through the *Builder*, from 1846 to the present day, and in the *Civil Engineer and Architect's Journal*, especially those by Mr. Scott Russell before the Royal Society and this Institute in 1847, and a few small pamphlets and incidental notices in books on other subjects. It is right to add that this is not a complete list, but only a selection.

Published abroad we have,—'Lachez sur l'Optique et Acoustique des Salles des Réunions Publiques,' a very practical and sensible little book. 'Rhode, Theorie der Verbreitung des Schalles für Bunkunstler,' a small but very valuable pamphlet. Observations by Chladni in his book, and in contributions to the 'Allgemeine Musikalische Zeitung;' and a few other papers and books. I am informed moreover that a French work of great value on this subject exists, different from any of these, but the title of which I have been unable to learn.

From almost any one of the first-named books a general knowledge of acoustics can be obtained; and if we make an attempt to sum up briefly what is known about sound, leaving out, as not essential to our present purpose, both the refinements of mathematical calculation and the elegant results of experiments on undulation, vibration, the pitch of musical notes, and other departments of the science, we arrive at a few definite results of philosophical inquiry which can be briefly stated, and will be enough for the present purpose.

Sound, then, may be regarded as motion made sensible to our ears; and the sense of hearing as a very refined, sensitive, and delicate sense of *touch*. A moment's thought will suffice to remind you, if this description seem at first sight startling, that there is *no* sound unaccompanied by motion, that there is but very little motion without audible sound; and lastly, that if motion exists but be so cut off from our ears that no communication can take place, we hear no sound.

Sound is not, like light, conveyed through an imponderable medium; it, on the contrary, travels through all the substances—solid, liquid, and aëriform, that surround us; and it is precisely that class of substances best suited to convey motion, which forms the best conductors of sound; while those bodies that deaden and destroy motion, deaden sound also. For example, a rod of elastic wood or of iron, will convey readily any motion from one end of it to the other, and such a rod forms one of the best known conductors of sound. A heap of sand will, be it only thick enough, check the force of the most powerful cannon-ball, and, were there no means of hearing *round* it, such a heap would equally deaden the report of the cannon; unless indeed the air lurking between the grains of sand conveyed some faint impressions to the listener.

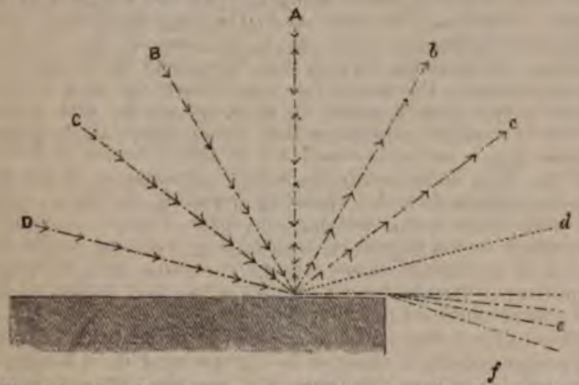
We are however more familiar with the atmosphere as the conductor of the sounds that reach our ears than with any other medium, and as it is through the atmosphere alone that the sounds heard in large rooms are transmitted, we shall have little occasion again to refer to the conducting properties of other media. The atmosphere under favourable circumstances will transmit to great distances any agitation that is roused in it. As an instance of this we may refer to the experiments of M. Biot. This gentleman having an opportunity of operating with a very long cast-iron pipe, forming part of an aqueduct in course of construction at Paris, found that even when the pipe was 1040 yards or more than half a mile long, the explosion of a pistol fired into it at one end would blow out a candle at the other, and that the lowest whisper at the one end was as distinctly audible at the other as to the speaker himself. This experiment succeeded better at night than in the day-time. Although however the air in a tube where any lateral escape is impossible shows this marvellous sensitiveness, we do not find a similar result from speaking in open, unconfined air. It is a matter of familiar experience that sound under these circumstances decays and dies away, till at last it ceases to become audible. This decay is only the natural consequence of the fact that the original force is constantly spreading through a wider and wider space, and is getting, so to speak, diluted. A familiar illustration to you all will be the gradually widening circles that spread on the surface of smooth water from a spot where you drop in a pebble, and which, weakening as they widen, at last fairly vanish into the flat unbroken lake.

The analogy between the progress of sound and that of water-waves thus roused, is however less complete than is ordinarily supposed, for it usually happens that from the first, sounds have an *initial* direction impressed upon them, and that they travel further in this direction than in any other. The most familiar instance to us all is that of the human voice, which is always head very much further in front of the speaker than it is at his sides or behind him. The human voice is not however an exceptional case; it is well to know that the larger number of sounds have something of this propensity. A good example is a tuning-fork; when the sound of this is excited it will be audible to a much greater distance square than cornerwise; that is to say, you will hear it better if the ear is in a line with the two arms, or in a line at right angles to one joining the two arms, than it will if the fork is turned a quarter round, so that a line joining the two arms would be at an angle of 45° to one drawn from the ear to the fork.

The decay of sound is very much prevented, not only by any initial direction it may receive, but also by any accidental circumstance that prevents the agitations in the air from spreading laterally, even if it be only one side that is confined. Thus sound will travel a long distance along the ground, and it will be very audible along a wall, because the angle formed by the wall and the ground forms two sides of a sort of tube, and thus prevents part of the lateral escape. There is an instance of this sort recorded in Dr. Hutton's Dictionary, that has been often quoted: a garden wall exists in Dorsetshire that will, he states, convey in this way a whisper 200 feet, without loss of distinctness.

Sound in an open atmosphere travels in a straight line; should it, however, encounter an obstacle, or pass the limit of any boundary, it always spreads to some extent behind that obstacle or boundary. For instance, in a church, an auditor exactly behind a stone pier and close to it will probably hear worse than if nothing were between him and the clergyman; but still, even close to the pier he will hear; and if, keeping always the pier between him and the speaker, he moves further back, he will soon reach a point where he will hear as well *with his ears* as if there were no obstacle. I use the words "with his ears" advisedly, because the eyes always assist us in our attention to public speaking, and, of course, this assistance would be lost in the situation I have supposed.

Sound, when it encounters an obstacle directly opposed to it is, however, beaten back, or reflected; the phenomenon of echo is familiar to all, and is the result of such a reflection sending back the sound from a considerable distance. It was laid down by Mr. Scott Russell, in the paper read by him before you on this subject, in 1847, that in the case of sound, the movements of which are closely allied to water-waves, reflection does not take place except where the wave impinges on the obstacle at an angle greater than about 30 degrees. Where the angle is less than this, the sound does not again leave the obstacle, but simply runs along the face of it—in fact, is conducted along it, in the manner we have just had occasion to mention. All, or almost all, whispering galleries are examples of this conduction, that at St. Paul's being a very good one. Should the angle, however, at which the sound falls approach nearer to a right angle, it will be reflected back, and will follow the same law as the reflection of light; that is to say, the angle of reflection will equal the angle of incidence, so that all sounds to be heard as echoes by the speakers must fall on a reflecting surface exactly at a right angle, and if a sound reaches any surface at an angle of, say 45 or 60 degrees from the right, it will be thrown off at the same angle 45 or 60 degrees, but to the left.



Thus, in the diagram, a sound uttered at A will be reflected back to A again; a sound uttered at B will be reflected back to *b*, and a sound from C will be reflected to *c*; but a sound uttered at D will not be reflected to *d*. It will travel along the wall and be heard at *e*, or if the wall ends will spread and be even heard at *f*.

It will be familiar to all that there are some echoes that can repeat one syllable, some two, some three, and so on, simply because in the one case longer time elapses than in the other before the echo gets back; and it will always be found when the sound takes longer time to make its journey to the reflector and back, it is because it has had a greater distance to go over. From this we gather that the speed at which sound travels, rapid though it be, is not so great but that the effect of even a moderate addition of length is quite perceptible in the longer time it takes to reach the ear. In this particular sound differs from light and electricity, which travel so fast that, unless with great distance, the time they consume in going cannot be detected.

The speed of sound in the atmosphere varies with the greater or less density of the medium. It has been very frequently measured, and Herschel gives as the result of the best investigations, that sound in dry air at the temperature of 62 degrees travels over 9000 feet in eight seconds. This statement is easily remembered, but it may be useful to add that 9000 feet or 3000 yards in eight seconds, equals 1125 feet or 375 yards in one second, or 12¾ miles in a minute.

As a practical application of this fact, I may extract from the same author the remark, that if music were performed in a room 53 feet long, with an echo in the extremity, each reflected note, should there happen to be a passage with as many as ten notes in a second, would exactly interfere with the following note sounded by the musician. Passages as rapid as this constantly occur in modern music, and it is not a very uncommon thing to hear them thus spoiled.

The varieties in the nature of sounds are very great. Thus we have music, articulate speech, and noise; we have variations of pitch, of quality, of loudness, of volume, of intensity, and of distinctness. We have in music combinations of sounds in succession to form melody, and simultaneously as harmony; and of sounds heard together, we have some combinations that are harmonious, and some that are discordant.

As an illustration of some of these peculiarities, let us suppose the string of a harp struck and left to sound. We hear a long, definite note gradually dying away, but which, faint though it becomes, still retains its pitch. If, now, we examine the harp-string, we find it constantly vibrating to and fro with great rapidity; as it gets to rest, its excursions on each side of the line of repose grow shorter and shorter, but they neither become more or less frequent than when they were most violent. It is clear that each movement of the string must rouse a movement in the air—in fact, strike a blow upon it; and we begin now to trace some connection as likely to exist between the regular recurrence of these blows and the equable pitch of the note the string gives out, and also between their diminishing vigour and the fading loudness of the sound. It is, in fact, as I dare say you all know, the regular recurrence of distinct impressions which occasions all prolonged sounds; and, with one or two exceptions, this is always a consequence of vibrations. The way in which the separate shocks on the ear produced by the vibrations get fused into one sound corresponds very closely to what happens to the sight when a spark of fire is swung round so rapidly as to appear a fiery circle: the impression of the sound on the ear, like that of the spark on the eye, does not die away the very instant the exciting cause stops; and if that impression be renewed before the recollection of it has had time to vanish, the sense of hearing loses the consciousness that any intermission has taken place.

(*To be continued.*)

RESTORATION OF LICHFIELD CATHEDRAL.

(*With an Engraving.*)

In this Journal for February last were given two views of the interior of Lichfield Cathedral, exhibiting the important restorations in progress in it, from the designs of Mr. G. G. Scott, R.A., with a detailed account of the work, and to which we beg to refer the reader. We now give another illustration from the same edifice, taken from the north aisle, looking westward, and showing the Ladye Chapel fitted up with seats, and the reredos restored to its ancient place to separate the chapel from the choir. This arrangement is made in order that a daily morning service may be read therein, in conformity with the provisions of the cathedral statutes.

SUSPENDED GIRDER BRIDGES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—Since the publication of your article on this subject, I have applied the method of investigation described in it to the question of the strength of a suspended girder with a travelling load, in order to compare the results with those of the approximate method formerly pursued by me, in which the effect of the chain in modifying the form assumed by the girder is neglected. I have not yet had time to write a detailed account of the investigation, but in the meanwhile I beg leave to send you the more important results.

	Approximate method.	More exact method (chain supposed inextensible).
Proportion of the length of the girder which, being loaded with the travelling load (commencing at one end) produces the greatest strain on the girder	$\frac{1}{3}$	$\frac{5}{12}$
Ratio of the load on the chain arising from the travelling load, to the amount of the travelling load	1 : 1	0·87 : 1
Proportion which the strength of the suspended girder ought to bear to that of a common girder capable of bearing the travelling load over its whole length ...	4 : 27 = 0·148 : 1	0·138 : 1

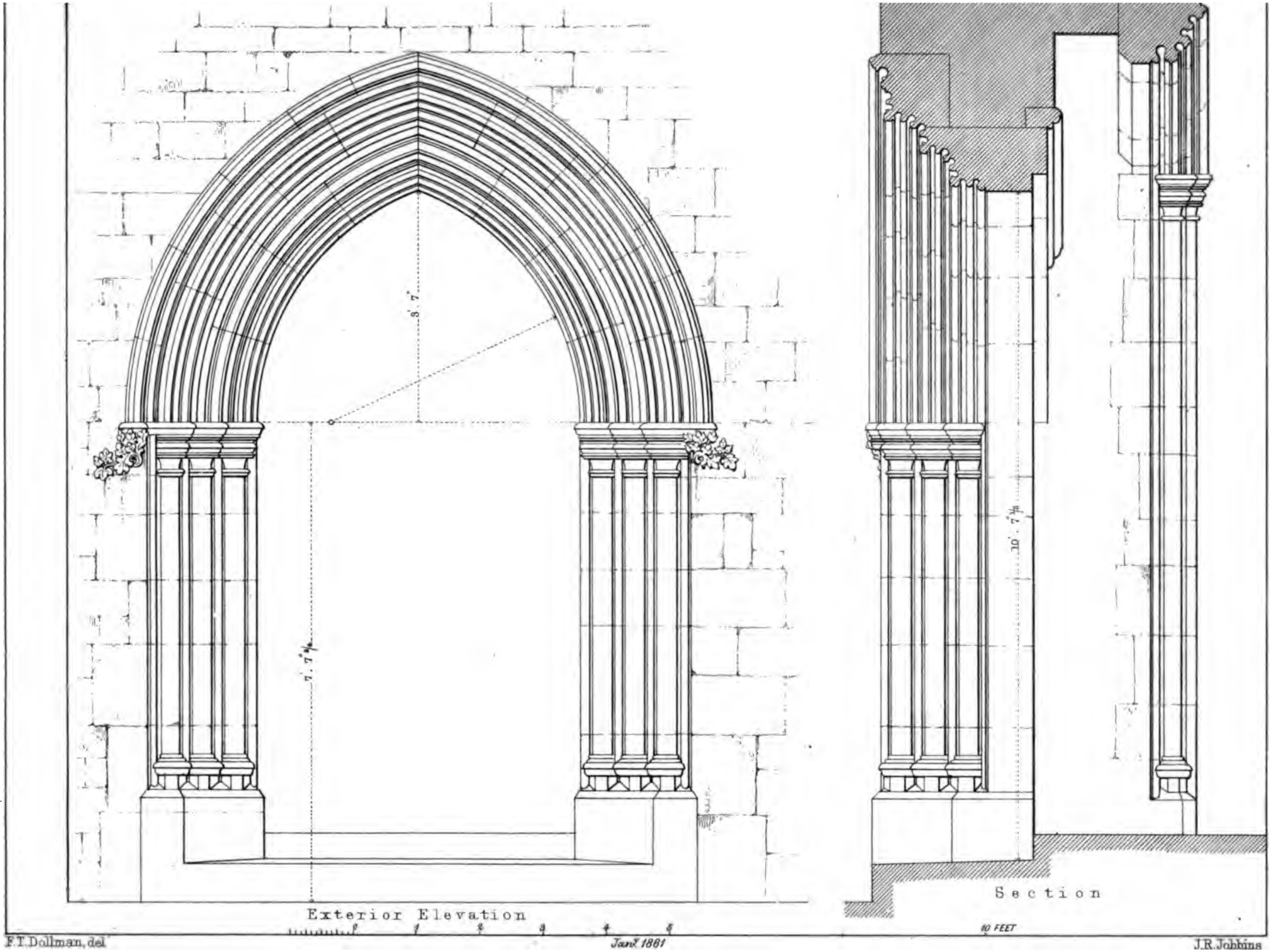
In the last of these results, which is the most important in practice, the approximate method errs *on the safe side* to the extent of about one-fourteenth.

By supposing the extensibility and figure of the chain to be such that its depression below the unloaded position when under its proof load is nearly equal to the deflection of the girder, when *unsuspended*, under its proof load, the results of the two methods are made to agree. But as the chain is never capable of so great a depression, the supposition of inextensibility is probably the nearer to the truth. If we take as the foundation for a practical rule the *mean* of the results deduced from these two suppositions, we find, for the proportion which the strength of the suspended girder ought to bear to that of a common girder for supporting the travelling load over its whole length, 0·143 : 1, or nearly *one-seventh*.

I am, &c.,

W. J. Macquorn Rankine.

Glasgow, 26th Dec., 1860.



F.T. Dollman, del.

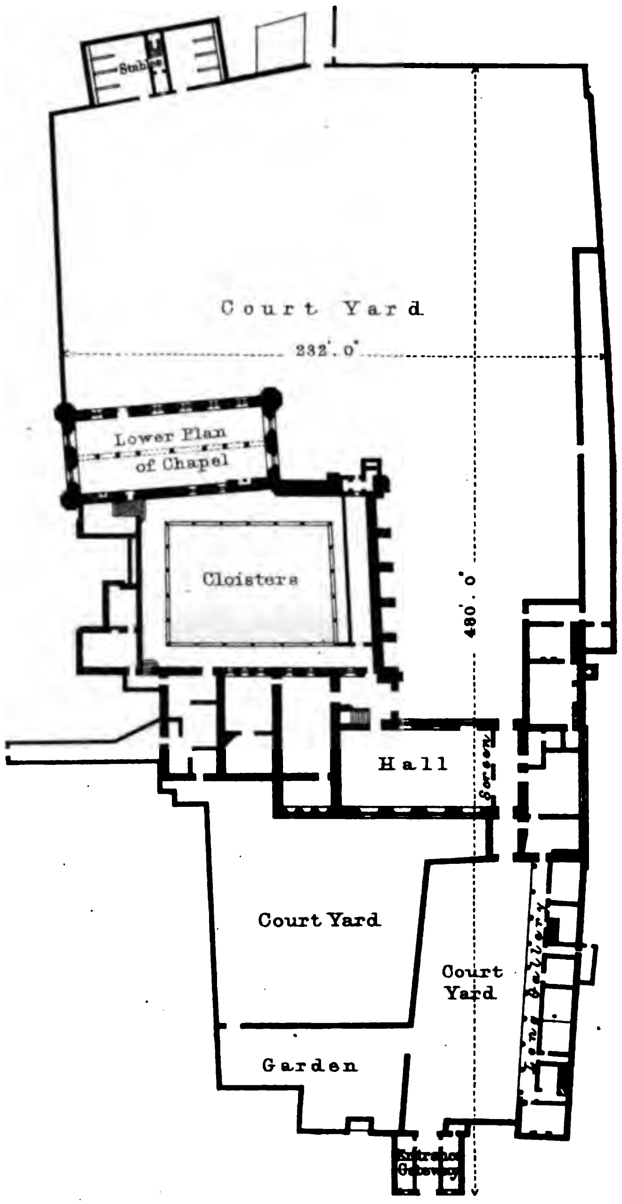
Jany 1861

J.R. Jobbins

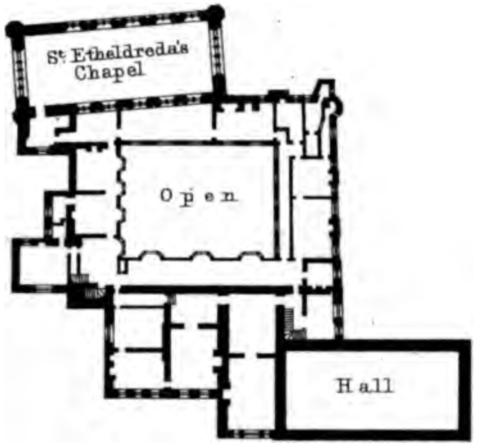
Sᵀ ETHELDREDA'S CHAPEL, ELY PLACE, LONDON

South West Doorway

PLANS OF THE EPISCOPAL PALACE, ELY PLACE, LONDON



GROUND PLAN.



FIRST FLOOR PLAN

From an original Plan taken in the year 1772

F.T.Dollman, del.

Jan.y 1861

J.R.Jobbins

HISTORY AND DESCRIPTION OF ELY PLACE, HOLBORN.

(*With Engravings.*)

The remark so often made, that strangers see and know more of London than Londoners themselves, is trite enough, but not the less true; for, of the thousands who daily traverse the streets of the huge metropolis, (the multifarious and matter-of-fact duties of life the end and aim of their hurried progress), the interest of comparatively but few is bestowed on the history or antiquarian lore of the mighty city to which they belong. In particular, to the great majority of those who daily pass the iron gates forming the entrance to Ely Place, Holborn, the fact that within those precincts there exists one of the most interesting Mediæval buildings of which London has to boast, is a circumstance altogether unknown. The street itself is a *terra ignota;* it has a staid, monotonous, uninviting aspect,—it is a very *cul-de-sac*, a whitened wall being its northern boundary. The aspect of its tenements significantly proclaims it the land of law and lawyers, and unless the necessity of professional consultation and advice drew them thither, but few would care to enter. Till within a comparatively recent period the writer of the following account was as little acquainted as his fellow-citizens with the architectural value and interest that is attached to the metropolitan palace of the Bishops of Ely, but having once visited the spot, he then saw enough to induce further investigation; and in the hope that in these days of appreciation of the beautiful in our Mediæval buildings, some attention may be directed to this most interesting but sadly-neglected example, he determined on sketching and measuring the whole, at the same time collecting all the reliable information connected with its ancient history. The entire detail will appear in these pages: the Ground or First Story Plan of the Palatial Buildings, with an Elevation and Section of the Chapel Doorway, will be found in the present number. The history of the palace is as follows:—

Ely Place, called at first Ely Inn, or Hostell, was built pursuant to instructions contained in the will of Bishop John de Kirkeby, who died in 1290, and bequeathed to his successors his mansion-house called the Bell, with nine cottages in Holborn, for their residence. William de Luda, the next bishop, carried into effect the wishes of his predecessor, and purchased other houses with lands adjoining, which he bequeathed to the church of Ely and his successors, on condition that his immediate successor should pay one thousand marks to his executors within three months after his confirmation; he also left two hundred marks to purchase the perpetual maintenance of three chaplains, to pray for his soul and the souls of the Bishops of Ely and their successors for ever, and three residences for them. John de Hotham, Bishop of Ely, by whom part of the choir in Ely Cathedral was erected, was also a considerable benefactor to the metropolitan palace, and in 1327 added the kitchen-garden, vineyard, orchard, and inclosed pasture, with other lands and tenements. In 1388 Thomas de Arundel, afterwards translated to York, and thence to Canterbury, among many other additions, built the gate-house fronting Holborn, on which, according to Stow, his arms were sculptured.

The patron saint of the chapel of the palace was St. Etheldreda, the foundress of the Cathedral at Ely. She was the daughter of Anna, King of the East Angles, and Hereswitha his queen, and was born about the year 630, at Ixning in Suffolk. On her first marriage with Tonbert, an East Anglian nobleman, the Isle of Ely was given her as a marriage dowry; and after Tonbert's death she married Egfrid, King of Northumberland. Bede asserts that with both her husbands she continued to live in a state of virginity, and having obtained Egfrid's consent, retired from the court, and took the veil at Coldingham. Her husband, however, retracted the permission he had given, and she again returned home, only to leave it once more for the Isle of Ely (her marriage portion), where she commenced the erection of the monastery, in which her brother Adulfus, the King of the East Angles, gave his aid. The monastery was of the Benedictine order, and the church, when finished, was dedicated in honour of the Blessed Virgin Mary, the foundress being the first abbess. The accounts of her mode of living, given by Bede, state that instead of linen she wore woollen garments; that she took food only once a day, except at the high festivals of the church, or during sickness, and that while her health permitted she never returned to rest after matins, but continued her devotions in the church till break of day. The fame of her sanctity, and the austerities of the monastic discipline observed, attracted numerous devotees, among them were her own relatives, Sexburga, her sister, Queen of Kent, Ermenilda, daughter of Sexburga, and Werburga her daughter, who each in turn succeeded to the office of abbess. St. Etheldreda died, as she had herself predicted, of a contagious disorder, and was buried in a common wooden coffin in the nuns' cemetery.

"Old John of Gaunt, time-honoured Lancaster," is said to have died here in 1399, the palace having been assigned to his use by Bishop Fordham after the destruction by fire of the Savoy Palace by Wat Tyler and his followers. The various additions and benefactions bestowed on Ely Place rendered it one of the most magnificent palatial residences, and some idea may be formed of its extent when it is stated that the entire area, with its court-yards, residence, and gardens, according to some writers, comprised no less than twenty acres of ground, by others considerably more. Its boundaries were, north by what is now known as Hatton-wall, south by Holborn, east by Saffron-hill, and west by what is now Leather-lane, originally termed Lither or Litter lane.*

In the days of its splendour, many and gorgeous were the entertainments held within the walls of Ely Place. At Michaelmas term, 1464, on the occasion of a call of new serjeants-at-law, a grand feast was given, to which the chief magistrate and the other civic authorities were invited. On sitting down to table, Baron Grey de Ruthin, Lord Treasurer of England, took the principal seat of honour, his occupation of which was disputed by Matthew Philip, the lord mayor, who maintained that as the king's representative in London he had by right the precedence of all persons within the liberties of the city. The treasurer refused to yield, whereupon the lord mayor resented the affront by withdrawing, and giving a sumptuous entertainment to his brother magistrates and the city companies, at his own residence.

In 1495 a grand banquet was given to King Henry VII. and his queen by the serjeants-at-law, to whom, as they had not a place of their own large or suitable enough for such entertainments, the use of the hall was accorded by the bishop.† Another and still more magnificent festival, which lasted five days, and of which Stow remarks that "it wanted little of a feast at a coronation," was held here in 1531, when the serjeants-at-law, eleven of whom had just been honoured by the coif, received as their guests Henry VIII. and his queen Katharine of Arragon (whose final divorce from her utterly unscrupulous husband was so shortly to follow), the foreign ambassadors, the judges of England, the barons of the exchequer, the master of the rolls, knights and esquires, the lord mayor Nicholas Lambard, whose claim of precedency was recognised in the fact that he dined at the chief table; the aldermen, the masters in chancery, serjeants-at-law and their wives,—the last, curiously enough, although the parties chiefly interested, keeping in their own chamber. At the same time banquets were held by the citizens and the various crafts of London in their several halls.

Amid all this revelry, however, the Bishops of Ely do not appear to have been unmindful of the more serious duties of their sacred office, and, in particular, it is recorded of Bishop West, who held the see of Ely in 1552, that he daily fed 200 people at the gate of the palace.

The intelligence of the death of Henry VIII. was communicated by Henry Ratclyff, Earl of Sussex, to his countess from Ely Place; and the palace became the residence of the Earl of Warwick, afterwards Duke of Northumberland, who held the council here which ultimately led to the deposition and execution of the Protector Somerset.

In the early part of Queen Elizabeth's reign, an act of parliament empowered the Sovereign, on the occasion of any vacancy occurring, to take any episcopal lands belonging to the see, the value being paid in tenths and impropriate rectories. This bill was opposed by the ecclesiastics generally, and in particular by Dr. Cox, afterwards Bishop of Ely, who was destined at no distant date to experience its effects in his own person. Sir Christopher Hatton commenced his public career, it is said, by obtaining her Majesty's approval of his proficiency in dancing, and after uninterrupted advancement at length attained the post of Lord High Chancellor. During the progress of his prosperity, he entertained a wish to possess a portion of Ely Place for his abode, and induced his royal mistress to negociate to that effect on his behalf. Accordingly we find that in 1576 the queen obtained from Bishop Cox, for her favourite, the lease of the gate-house (except two rooms used as prisons for those who were delivered in execution to the bishop's bailiff, and the ground-floor rooms, appropriated to the porter's use), the first courtyard within the gate-house to the long gallery dividing it from the second, the stables there, the long gallery with the rooms above and beneath it, and some others, with the gardens and orchards and fourteen acres of land, for a term of twenty-one years. The rent due at Midsummer for the land, £10 per annum, and ten loads of hay; for the gate-house and garden, a red rose, with a reserved right to the bishop and his successors to walk in the garden, and to gather twenty bushels of roses annually therefrom. The property was so much appreciated by Sir Christopher Hatton that he expended on improvements to the house and grounds £1995 4*s.*; and calculating on the influence he possessed with the queen, a grasping spirit of cupidity next induced a wish to obtain, through her majesty, an alienation of the property in perpetuity from the bishop. Elizabeth thereupon wrote to Bishop Cox, requesting that he would demise the property to her until such time as the see of Ely should indemnify the Chancellor for the great expense he had incurred, by the repayment of the £1995 he had already disbursed, as well as whatever else he might yet expend upon the property. In answer to this summary request he made an earnest protest, alleging, among other reasons for non-compliance, that "he could scarcely justify those princes which transferred things appointed for pious uses unto uses less pious." This remonstrance, however, proved in vain; and after enduring much persecution, he was compelled to submit to the conveyance of the property to her majesty for £1800, reserving, however, the proviso that the see of Ely should retain the power of redeeming the property on payment of such sums as had been expended thereon. The result of this negociation was the re-conveyance of the land, &c., forthwith to Sir Christopher Hatton. After the death of Bishop Cox, in 1581, the see of Ely remained vacant for eighteen years, during which time Queen Elizabeth received the whole profits, the spiritual administration of the diocese being under the control of commissioners appointed by the Archbishop of Canterbury. At the end of the year 1599, she sent a *congé d'elire* to the dean and chapter, and Dr. Martin Heton became bishop. This prelate entertained and expressed an opposition to the alienation of the estate similarly to his predecessor, whereupon the virgin queen, enraged by what she deemed his contumacy, sent him the following well-known and characteristic, but not over-refined epistle:—"Proud prelate,—I understand you are backward in complying with your agreement; but I would have you know that I, who made you, can unmake you; and if you do not forthwith fulfil your engagement, by God! I will immediately unfrock you.—Elizabeth."* The bishop was sufficiently prudent to prevent the execution of this threat; and, in consequence, Sir Christopher Hatton thenceforth retained the property unopposed. He changed the name of the residence to Hatton House, and continued to live there till, on the 25th of November, 1591, he died—the victim of a broken heart, occasioned by the exacting demands for payment of £40,000 of arrears due to the queen, which he had hoped would have been remitted, and which he was unable to pay.

---

* In the wall of the Mitre Tavern, in a court leading from Hatton-garden to Ely-place, is a mitre sculptured in stone, and bearing date 1546. It is asserted that this was originally fixed either in the palace walls, or over the entrance gate-way, but the authenticity of this tradition and the alleged antiquity of the mitre is very apocryphal.

† The gardens of Ely Place were noted for the choice fruit they contained. Allusion is made to this by Shakspere, in the play of *Richard III.*, where the Duke of Glo'ster accosts the Bishop of Ely, John Morton—

> "My Lord of Ely, when I was last in Holborn
> I saw good strawberries in your garden there:
> I do beseech you send for some of them."

An account of the architecture of this very interesting example of Mediæval London, with a description of the engravings now given (as well as of the remaining plates, wherein all the details of the Chapel will be fully exhibited), will appear in our next number.

---

* Sir Harris Nicolas, in his Life of the Chancellor Hatton, says, no better authority exists for this letter than the 'Gentleman's Magazine,' vol. lxxix. part i. p. 186, where it is said to be copied from the Register of Ely. It has been sometimes differently worded, and its authenticity is considered rather uncertain.

ON THE CONSTRUCTION OF A RIGID SUSPENSION BRIDGE.

By C. Köpcke, Geestemünde, Hanover.

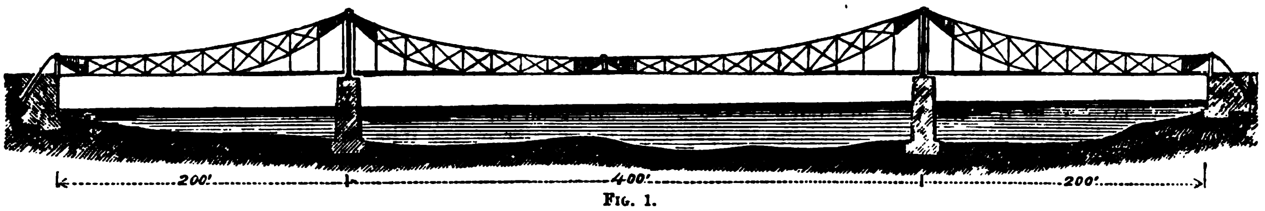


Fig. 1.

The vertical vibrations to which the common suspension bridges are to a great extent subjected have much restricted the application of these structures and rendered them unsuitable for railway purposes. Several proposals have lately been made to stiffen the suspension bridges, but none of these appear to answer the purpose in a simple and safe manner. The construction to be here described, as shown in Fig. 1, consists essentially of two rigid beams suspended on the pillars and connected by means of hinges, and so curved as to sustain only a strain similar to that of a chain when loaded equally over the whole length, but being strong and rigid enough to counteract the undulations resulting from a heavy transit load (Fig. 2). The calculation of the strain in the different parts is based on the theory of the line of tension, which has here a similar application as the line of pressure in the calculation of arches. The essential difference however is this: that in an arch several lines of pressure can always be drawn, everyone of which gives a different result in respect to the strain on the material, so that it remains undecided which line of pressure will actually come into operation. Moreover in an arch the line alters its form according to the temperature, and in consequence of the starting points at the crown and in the abutments not always being the same.

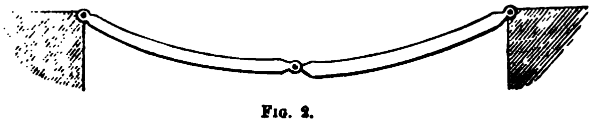


Fig. 2.

In using hinges which will allow of the beams moving vertically by change of temperature at the points of suspension, as well as in the middle of the opening, the line of tension is at once fixed; it must necessarily pass through those three points, and its form can be ascertained with the utmost precision for any position of the load brought upon the bridge.

Now, when the form of the line for a special case is found it will be possible to calculate the strain on the main chain as well as on the bottom flange, both being connected by lattice-work or diagonal bracing.

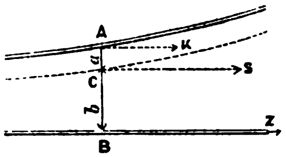


Fig. 3.

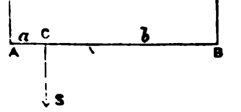


Fig. 4.

Let A (Fig. 3) be the main chain, B the bottom beam, and C a point of the line of tension calculated for a special case, having the distances a and b from the chain and the beam respectively. The horizontal strain in the line of tension may be called S, that on the chain K, and that on the beam Z; then there will subsist a relation between the different strains similar to that of a beam resting on two supports and being loaded at a certain point of its length (Fig. 4), viz:—$K \cdot a = Z \cdot b$, and $Z + K = S$, so that $K = S \cdot \frac{b}{a+b}$, and $Z = S \cdot \frac{a}{a+b}$.

To get the calculation of the line of tension as simple as possible, suppose both the constant and the moving load uniformly distributed over the horizontal projection, whence the line of tension will be a parabola. In case of the load not being spread over the whole length, the line of tension will be composed of parts of two different parabolæ. The tension of the main chain or rope when loaded on its whole length is so easily determined that it is not necessary to give the calculation, but to take under consideration here only the bottom flange and the lattice-work or diagonal bracing, when one-half of the span, or what will be the same, one of the two suspended beams, is continually loaded with the passing weight, and the other half unloaded (Fig. 5).

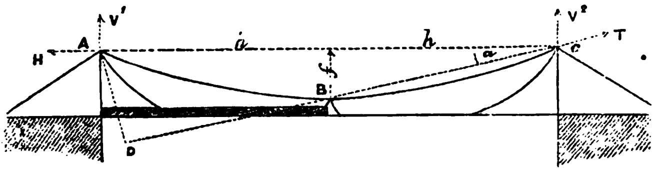


FIG. 5.

Let the half-span be $= h$, and the height of the points of suspension above the junction in the centre $= f$, the permanent load $= q$, the moving load $= p$, per unity of length.

Now we may assume the unloaded half $\overline{BC}$, considering its construction as a beam, to be a firm connecting piece between the points B and C, as it might also be effected by a rectilinear rope. The pressure on the support C, caused by the moveable load may therefore be derived from the strain T of a rope $\overline{BC}$, supposed to be weightless. Produce the line $\overline{CB}$ to a point D, whence a line drawn normal to DC will pass through it, and let the length AD be equal to s, then we have the equation:

$$T . s = \frac{ph^2}{2}, \text{ since } s = 2h \sin a,$$

$$\text{and } \sin a = \frac{f}{\sqrt{f^2+h^2}},\ T = \frac{ph}{4f}\sqrt{f^2+h^2}$$

The vertical component of this strain will be $= T \sin a = \frac{ph}{4}$

and the horizontal component $= T \cos a = \frac{ph^2}{4f}$.

The permanent load q, uniformly distributed over the whole length, causes in each of the two supports a vertical pressure $= qh$, and a horizontal strain $= \frac{qh^2}{2f}$; we have therefore the whole pressure in A,

$$V_1 = qh + \tfrac{3}{4}ph = (q + \tfrac{3}{4}p)h,$$

and in C,
$$V_2 = \left(q + \frac{p}{4}\right)h;$$

whereas the horizontal strain throughout the whole length is

$$H = \left(q + \frac{p}{2}\right)\frac{h^2}{2f}$$

Having the value of HV_1 and V_2 it will now be possible to find the semi-chords as well as the heights of the two parabolæ which compose the line of tension and join in the middle hinge, whereby the line of tension will be entirely fixed (Fig. 6). As regards first the loaded half, the horizontal distance h_1 of the vertex from the point A can be deduced from the vertical pressure in A as follows: $(q+p)h_1 = V_1 = (q+\tfrac{3}{4}p)h$, therefore

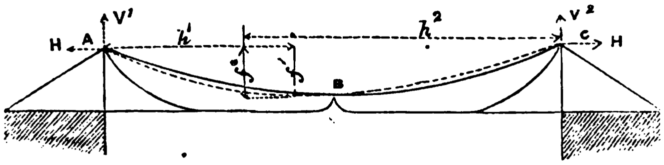


FIG. 6.

$$h_1 = \frac{q+\frac{3}{4}p}{q+p}h.$$

Further, the vertex of the parabola lies at a depth f_1 below the level of the points of suspension, to be found by the relation

$f_1 H = (p+q)\frac{h_1^2}{2}$, whence it becomes

$$f_1 = \frac{(q+\frac{3}{4}p)^2 f}{(q+p)\left(q+\frac{p}{2}\right)}$$

Thus the parabola which represents the line of tension in the loaded half can be drawn, the values of f_1 and h_1 being known. As regards the unloaded half, it is evident that the geometrical tangents to the line of tension at the middle hinge must be directed upwards towards C, because this hinge has to transfer the weight of $\frac{ph}{4}$. The vertex of the completed parabola of which the line of tension between B and C forms a part, lies beyond the middle towards A, and as we call q the weight upon the unity of length in a horizontal distance from B equal to $\frac{ph}{4q}$, then the semi-chord h_2 of the parabola from C to its axis will be

$$h_2 = h + \frac{ph}{4q} = \frac{p+4q}{4q}h$$

The rise f_2 of this parabola may be determined by the relation $H . f_2 = \frac{qh^2}{2}$, and substituting for H its value it becomes,

$$f_2 = f\frac{(p+4q)^2}{16q^2+8pq}$$

Thus the values f_2 and h_2 being known, the part of the parabola which represents the line of tension in the unloaded half is also determined.

By means of the relation between K, S, and Z, the strains on the chain and bottom flange can now be determined for every special case. It is a matter of course that the most unfavourable mode of loading must be always assumed. In ascertaining therefore the strain of the chain, we have to consider the bridge as completely loaded, while only one-half of this load is to be taken into account in computing the tension of the lower member. To illustrate the case by an example, suppose

The moving load $p = 3500$ lb.
The permanent weight $q = 2000$ lb.
The span $2h = 400$ feet
The height $f = 33\frac{1}{3}$ feet
The height of the middle hinge above the bottom flange $= 8$ ft.

Then the greatest strains on the chain and the bottom flange are to be calculated as follows:—

In substituting the figures in the equations above we get these results:

$h_1 = 168{\cdot}18$ feet. $f_1 = 34{\cdot}565$ feet.
$h_2 = 287{\cdot}5$ „ $f_2 = 36{\cdot}76$ „

Let the middle hinge be now the point of origin, and the horizontal line through it the axis of abscissæ: then we get the following table of ordinates for the different lines of tension in each half of the bridge:—

ABSCISSÆ (Foot).	ORDINATES (Foot).		
	Total Load.	Partial Load.	
		Loaded half.	Unloaded half.
20	0·333	−1·056	1·71
40	1·333	−1·154	3·80
60	3·000	−0·274	6·25
80	5·333	1·583	9·05
100	8·333	4·419	12·21
120	12·000	8·231	15·71
140	16·333	13·022	19·56
160	21·333	18·790	23·80
180	27·000	25·536	28·39
200	33·333	33·333	33·33

The horizontal strain in the line of tension when the whole bridge is loaded is equal to

$$\frac{(p+q)h^2}{2f} = \frac{(3500+2000)200^2}{2 . 33{\cdot}33} = 3{,}333{,}333 \text{ lb.}$$

The strain at the point of suspension

$$= \sqrt{3{,}333{,}333^2 + (5500 . 200)^2} = 3{,}508{,}720 \text{ lb.}$$

The horizontal strain in case of only one-half of the span being exposed to the moving load is found to be $H = \left(q + \frac{p}{2}\right)\frac{h^2}{2f}$ or, in figures, $H = 2{,}250{,}000$ lb.

The strain at the point of suspension on the side where the bridge is loaded amounts to

$$=\sqrt{2{,}250{,}000^2+(168{\cdot}18\;.\;5500)^2}=2{,}433{,}000\text{ lb.}$$

and on the unloaded side,

$$=\sqrt{2{,}250{,}000^2+(287{\cdot}5\;.\;2000)^2}=2{,}322{,}000\text{ lb.}$$

When the bridge is not loaded at all, the horizontal strain equals

$$\frac{qh^2}{2f}=1{,}200{,}000\text{ lb.}$$

and the strain at the point of suspension,

$$\sqrt{1{,}200{,}000^2+(200\;.\;2000)^2}=1{,}265{,}000\text{ lb.}$$

If we allow now a strain of 8500 lb. per square inch, then the section of the main chains (which may be three in number for a double line of rails) must amount to $\frac{3{,}333{,}333}{8500}=392$ square in., or for each chain 131 square inches.

Concerning the bottom flange it must be remarked, that as it lies horizontally supporting the ends of the cross beams, the area of its section must be varied. At 20 feet distance from the middle hinge we have the ordinate of the main chain $=0{\cdot}333$ feet, that of the line of tension on the loaded side $=-1{\cdot}056$ feet; the depth of the bottom beam below that line $=8-1{\cdot}056=6{\cdot}944$ feet. The horizontal strain in the line of tension, the bridge being loaded unequally, $=2{,}250{,}000$ lb. This strain is transferred partly to the chain, partly to the bottom beam, in proportion to the distances of each from the line of tension, so that the strain coming on the beam equals

$$Z=\frac{0{\cdot}333+1{\cdot}056}{8+0{\cdot}333}\;.\;2{,}500{,}000\text{ lb.}$$

$$Z=375{,}000\text{ lb.}$$

At 60 feet distance from the middle hinge we get

$$Z=685{,}000\text{ lb.}$$

At 100 feet distance, $Z=564{,}000$ lb.

At 140 feet distance, $Z=331{,}000$ lb.

Thence to the point of suspension a separate iron is applied of such a form that the strain to which it is exposed remains constant. On this part of the bridge the roadway is merely supported by suspension rods (fastened on the main beams), as no diagonal trussing is required. These beams have no support at the ends, but provision must be made that no horizontal oscillation can result from their being at liberty to move laterally. On the unloaded side of the bridge pressures result in the partly-horizontal partly-curved bottom beam, because the line of tension passes above the main chain; but these pressures, which may be found by the above table in the same manner as the strains are found, are of no particular interest, since they become smaller than the strains at the same points when the bridge is loaded on this side. If it be considered preferable to avoid all pressure in the bottom beam, it would only be necessary to draw the elevation of the chain according to the line of tension in the unloaded side in case of single-sided loading; the consequence hereof would be that the bottom flange would partake of the strain also in case of uniform loading, and therefore require to be made stronger, but always considerably less than double what is here calculated.

The differences of strain in the bottom member are compensated by the lattice-work or diagonal bracing (shearing effect), and may be calculated here in a similar way as in ordinary beams. This shearing effect is here considerably less than in beams without strain in the axis, therefore the lattice-work can have small dimensions and great openings. Plate iron of such a thinness as would be requisite here is hardly applicable; but it may be mentioned, that with respect only to the shearing force the vertical plates (that is, of all three beams) would require a weight per square foot of elevation—

At 20 feet distance from the middle hinge, of ...	3·057 ℔
At 40 feet distance	2·393 ℔
At 100 feet distance, only	0·064 ℔

supposing the strain on the square inch to be 5000 lb.

In arranging diagonal braces with 45° inclination, so as to resist the pulling forces only, and vertical posts against the crushing forces, this brace-work would require a weight nearly five times as much as that just calculated for plate iron.

The weight of a bridge of 400 feet span, approximatively calculated, stands thus:—

	℔
Main chains, of an average sectional area of 136 square inches, 3 . 136 . 400 . 3	489,600
Bottom flange and beam carrying the railway— 2 . 3 . [60 feet (40 sq. in. + 60 sq. in.) + 140 feet . 80 sq. in.] =	103,200
The brace-work has an average weight of 6 lb. per superficial foot of the total area between frames— 3 . 2 . 2400 . 6 =	86,400
Cross-beams, arranged in plan like a net, to stiffen the bridge laterally against the effect of wind and passing loads—320 in number, 21 feet long, and weighing 30 lb. per foot run ...	201,600
Suspension-rods, 1450 feet at 6 lb.	8,700
Wind-braces between the main chains	10,000
Rivets, &c.	30,000
Total weight in lbs.	929,500

$$\text{Making per foot run, }\frac{929500}{400}=2324\text{ lb.}$$

Besides this should be included 200 lb. per foot run for rails, sleepers, and planking, increasing the constant weight to 2524 lb. per foot run, whereas before only 2000 lb. was assumed. This difference properly demands a fresh calculation under the supposition of 2524 lb. constant weight, but as it is not intended here to give an exact estimate for a special case, it will suffice to remark, that in keeping the dimensions found above, the strain on the main chain would increase from 8500 lb. to

$$\frac{3500+2524}{3500+2000}\;.\;8500=9290\text{ lb. per square inch of section.}$$

It is evident that this system is also applicable to arched bridges, and that here the same advantages are to be obtained as in applying it to suspension bridges. The principal defect of wrought-iron arched bridges as they are now usually constructed (and the best model of which is considered to be the Pont d'Arcole, Paris, projected by Cadiat and Oudry), cannot be obviated without the introduction of a hinge in the centre of the arch. For, if the arch is made somewhat high in the soffit in order to get it sufficiently rigid, the structure will be endangered by the influence of temperature. The increase of temperature produces an extension of the whole arch and a rise in the middle, the consequence of which will be that the upper flange becomes more lengthened than the lower one. The amount of these mutations effected by the changes of temperature depends on the height of the arch. The Pont d'Arcole has ribs of only small rise in the centre, and therefore the influences of temperature are here less considerable; but this advantage is obtained at the expense of the strength of the ribs, which are more liable to deflect when a load passes over the bridge. This disadvantage is fully obviated by introducing a hinge in the centre—the arch can in that case freely extend and rise without being exposed to a dangerous strain, and the height can be made great enough not to admit of any detrimental deflection. As above defined, hinges should also be introduced at the abutments.

All uncertainties respecting the amount of the strain on the material are now entirely removed. The amount of pressure can therefore be distinctly determined, so that all strains to which any parts of the structure may be subjected can be computed beforehand with exactness.

◆

Hall and Wells' Submarine Cable.—At the meeting of the Literary and Philosophical Society on the 11th ult., Dr. Fairbairn exhibited four specimens of Submarine Telegraphic Cables, as constructed by Messrs. Hall and Wells, of London. This cable has a copper wire insulated by india-rubber in the centre for the transmission of the electric current. Outside of this are twenty longitudinal strands of hemp steeped in pitch and cork dust, and eight steel wires braided together with twenty-four strands of hemp saturated with Stockholm tar. The specific gravity of the cable in sea-water is 1·4, and its weight in air 0·82 ton per mile. The length that would break with its own weight when suspended in sea-water is 10,810 fathoms; its tensile strength being 2·875 tons. Dr. Fairbairn presented an account of experiments which had been made on the elongation of a sample of the cable 20 feet long by the application of different tensile forces. With a force of 4480 lb. there was an elongation of half-an-inch, and after the weight had been removed the cable was found to be permanently stretched $\frac{3}{16}$-inch. With a force of 6440 lb. the cable broke after having stretched $1\frac{1}{16}$ inch.

ON THE ORIGIN AND DEVELOPMENT OF THE USE OF CRYPTS IN CHRISTIAN CHURCHES.*

By Arthur Ashpitel.

There are few objects, the work of man's hand, that affect the mind with more solemnity than the crypt of a cathedral. The massive character of the edifice, which not only carries its own "arched and ponderous roof," but also the more imposing and heaven-aspiring building above it; the sepulchral aspect of the vaults, the dim, broken light, struggling faintly from aisle to aisle, which scarcely is sufficient to guide the gazer's feet; the enduring solitude; the silence, broken perhaps at intervals only by the distant roll of the diapason of the organ, descending from above through the massive masonry,—all tend to affect the mind with the deepest solemnity: and yet it is curious that less perhaps has been written as to these extraordinary fabrics than any parts of our noble ecclesiastical edifices. They seem to have been passed over as certain substructures necessary to carry the building above, which being there, were used for the purposes of sepulchral rites, or of sepulture itself, but of whose origin or history little or nothing can be related. It is my purpose to endeavour to give some slight sketch of the origin of these structures, and the progress made in their size and importance for many generations, till from some unknown cause they almost suddenly ceased to be erected as parts of Christian churches.

The construction of subterranean chambers of all kinds was probably suggested by the existence and use of natural caves. The desire to enlarge these for the purposes of dwelling, concealment, or stowing away articles of value, naturally would lead to the formation of rock-cut caverns by excavation. It appears also from Scripture that such caves were early used as places of sepulture. Thus we all remember in the Book of Genesis that Abraham purchased the cave of Machpelah from Ephron the Hittite for 400 shekels of silver, that he might inter the body of his wife Sarah. The earliest subterranean excavations are probably the catacombs of the Egyptians, which are described by most authors, and particularly by Pococke. He gives account of some to the south of the Pyramids of Saccara, others near Alexandria; and particularly some of extensive dimensions near the old canal of Canopus. These last consist of large galleries running out of each other at right angles, in the walls of which are a number of excavations ranged side by side, more resembling the boxes in which we keep our papers, and which we familiarly call pigeon-holes, than anything else. He has shown them in ranges; each opening large enough to hold a mummy placed endways, each range containing eight openings, side by side, and three in height. Whether these suggested the catacombs of Rome and of Sicily it is but of little use to inquire, as the subject more immediately before us is the crypt itself.

The word, as we all know, is derived from the Greek *κρυπτω*, I hide, or conceal. But it seems curious that the word *κρυπτη*, as applied to any similar construction, is of rare, if not of solitary occurrence among the Greek writers. It is used by Athenæus in describing the works of Ptolemy Philopater. In this passage the word *κρυπτη* seems to mean a vaulted roof, and cannot be said to apply to a *subterraneous* building, but as the chamber it covers is expressly called *υπερωον*, or an "upper chamber." The Latin word "crypta" (no doubt derived from the same root) is also of rare occurrence. We find it in Juvenal, and there evidently it means part of the great sewer, or "cloaca maxima." It is used by Petronius (p. 47, Amst. 1669) in a passage which, according to Burman means the same thing; but Erhard, on the authority of an old glossary, considers it to be a subterranean chapel dedicated to the god Priapus.† In Seneca (ep. 57), and in a passage in Suetonius (Caligula, 58), the word crypta‡ clearly means a subterraneous tunnel or passage. Vitruvius uses the word but once (lib. vi. 8), and that in a list of offices necessary to a country-house, viz.:—"Stables and sheds in the vestibule (or outer courts), and crypts (cryptæ), granaries (horrea), and apothecæ (stowage places, particularly for wines), and other places for preserving fruit, which should be in the houses." An attempt has been made to show, as Varro de R. R. (lib. i.) tells us the corn was often kept in pits underground, that the "cryptæ" must necessarily be subterraneous; but as "horrea" clearly are the granaries, the proof is defective. In fact, all we can gather from the passage in Vitruvius is that "cryptæ" were used among other places, "ad fructus servandos."

It is therefore doubtful whether the word in classic times ever had the signification which we now give to it; still less should we confuse it with the word "crypto-porticus," a construction which resembled rather the walks of one of our cloisters than what we call a crypt: although we gather from the description of Pliny (ep. ii. 17),* and from Sidonius Apollinaris (ii. 2), that these walks were partly sunk in the ground to keep them cool. The best example extant is perhaps that round the garden in the villa of Diomedes at Pompeii.†

But before going directly into the history of the crypts in Christian churches, it will be well to advert to some of the Etruscan sepulchral chambers, which resemble very closely the early crypts, and by which they probably may have been suggested. Like the tombs of the Greeks, they were always below ground; in fact, where this was difficult to accomplish from the flatness of the country, a circular apartment was built, and the earth piled over it so as to completely cover it. The Greek tomb was generally a sort of chamber to inclose the body; sometimes a mere stone coffin,—sometimes very like our own family vaults, but without the arch. The Etruscan tomb, on the contrary, was the banqueting-hall of the departed spirits.‡ Hewn out of the solid rock, the ceiling was nevertheless carved to resemble the timber rafters of a chamber, the walls panelled like wainscot,—benches, armchairs, footstools, tables, all hewn from the solid rock, fill the chambers; while the walls are hung with weapons and tripods, lamps and other utensils lie about, and the panels are filled with pictorial representations and stucco figures. There is, in fact, little doubt that the Etruscan subterranean chamber was a complete copy, in design, decoration, and arrangement, of an Etruscan dwelling-house. A plan and interior view of the famous tomb at Tarquinii, commonly called that of the Cardinal, is given by Canina ('Etruria Mar.' pl. 84). The plan is that of a square chamber, cut out of the solid rock, the ceiling or roof of which is supported by four solid piers, strongly resembling that of some of the early Mediæval crypts.

It would now be a very curious and interesting inquiry as to the customs of sepulture among the ancients by burning or by burial; but it would, though bearing directly on the subject, be too wide and extensive a research for the present occasion. Suffice it to say, that the customs of sometimes burning, and sometimes burying the dead, were practised by all the three nations—the Greeks, Romans, and Etruscans. A very high authority, the Canon di Iorio, who had excavated as largely as any one, says ('Sepul.' p. 28) that, among the Greeks, not more than one body out of ten was burned; while among the Romans not more than one out of ten was buried. In fact, it appears from a passage in Homer ('Iliad,' vii. 334), that burning was practised among the Greeks as a matter of convenience, for Nestor recommends that the bodies which had fallen in battle should be sought out and burned, that the remains might be more easily carried to their children when the heroes returned to Greece. Among the Romans, we have the direct testimony of Pliny ('Hist. Nat.' vii. 55) that in ancient times their practice was to bury the dead; and this prevailed among the old families even till a late period; Sylla being, as he informs us, the first of the Gens Cornelia whose body was burned.

At the time of the Christian era, as we shall see, the practice became almost universal; but, as Christianity became more diffused, it gradually fell into disuse, till Macrobius ('Saturn.' vii. cap. 7), who is supposed to have written his work about A.D. 420, tells us, in his days the practice of cremation was quite left off, and it was known to him only from reading.

But whether the one or the other of the modes were preferred by the Romans, one rule was strictly observed. It was a law of the Twelve Tables neither to burn nor bury a dead body within the city walls, a space which of course included also the "Pomœrium." The words are given by Cicero in his treatise ('De

---

* Read at the Royal Institute of British Architects.

† Some have supposed the crypt alluded to was the famous one at Naples, in which was a chapel to this god. The whole passage is very obscure, especially as the text is imperfect, and what took place was "ante cryptam."

‡ "Cum in crypta per quam transeundum erat, pueri nobiles ex Asia....ut eos inspiceret hortareturque restitit." Caligula had risen, and was going out, when he was killed in this crypt.

* See also lib. v. ep. 6. "Sub est cryptoporticus *subterraneæ similis*. æstate incluso frigore riget. contenta que aëre suo nec desiderat auras nec admittit."

† The *villa suburbana* of Gell: Pomp. vol. 8. There was a terrace above the crypto-porticus, in which were a large number of empty amphoræ stuck upright in dry sand. A conjecture was ventured that these were put out to be washed out preparatory to the vintage. The destruction of Pompeii took place at the end of August.

‡ See also Dennis, 'Cities and Cemeteries of Etruria,' i. 262; also, *ib.* i. lxvi. page 59, 157, &c. &c.

Legibus,' l. 2) thus, "Hominem mortuum in urbe ne sepelito neve urito;" and this law prevailed for many centuries after the Christian era.

One great barrier which the early Christians invariably opposed to the persecutions of their heathen rulers was this,—that they scrupulously obeyed the laws of the country wherein they may have sojourned, or of the superior who governed; provided that these laws did not possibly command them to do anything absolutely contrary to their faith, the most prominent of which was the sacrificing to idols. In other respects they declared themselves the most faithful of citizens. Accordingly, we find there were no burials within the bounds of any cities, either Christian or pagan, for several centuries after the Christian era.

The Roman antiquary will remember how he must have been struck to see the huge vestiges of tombs and monuments stretching away across the Campagna, down the Flaminian, Salarian, Prænestine, and above all the Latin and Appian Ways. For miles the memorials extend along both sides of the road leading to the city; for miles, tombs—some of gigantic, some of moderate, and some of very small proportions—line the roads leading to the refined city that once governed the whole world, and must have given a strangely impressive effect to its entrance—that the introduction to the presence of the greatest among the living should have been through the silent ranks of the remains of the dead.

But the Christian feeling revolted from the practice of burning the dead; and this variation from the conventionalities of society (as it is the fashion to express ourselves in this day) gave rise to great prejudice on the part of the pagans against the Christians at that time. Many of my hearers must have read the delightful apology of Minucius Felix for the Christian religion. This beautiful little treatise, in manner, language, and elegance worthy to be compared to some of the best philosophical essays of Cicero, introduces the Christian Octavius, walking with his heathen friend Cæcilius, at Ostia. The mighty ocean, the everlasting hills, are before them, exhibiting the unlimited power of the Deity; while the occupation of a few boys, who are amusing themselves with pitching smooth pebbles into the sea, and watching them spring from wave to wave, is a fine illustration of the vanity, the nothingness of human pursuits. The friends begin o moralise, and the pagan remonstrates with his Christian companion as to some gross charges brought against them, such as worshipping an ass's head,—an accusation, by the way, which it appears from some coins may not have been unfounded as against that strange sect the Gnostics, who represented their deity, Abraxus, with such a head. After this had been refuted, Cæcilius begins to blame the Christians for some peculiarities he deems absurd. He objects that they are not content, like other people, that their dead bodies should be burnt; because they fancy, if they should be deposited in the earth instead, they are to rise again to the skies at some future time. But the Christian apologist answers him, "What care we if our bodies are dried up in the sands, or perish in the waters, or are consumed into cinders, or are dissolved into vapour—the Almighty receives the elements. Nor do we, as you believe, fear any damage to the soul from any manner of sepulture, but we follow that which we consider the older and better method, of burial in the earth." I will not pursue the eloquent and touching explanation of the Christian—it is too long for our purpose. I only quote a short part, to show how the customs of the heathens and Christians differed at that time, and how the latter adhered to the practice of inhumation. But this was written scarcely a century after the apostolical period, and before the more organised persecutions which followed, the history of which, though deformed by ridiculous legends and exaggerations, is still a very great and affecting part of the annals of our religion.

To go into this history would be not only beside the purpose, but far too extended an inquiry for the space we have. Suffice it to say, from the exigencies of the persecution of the Christians arose two most important circumstances—the use of the basilica as a place of worship, which afterwards became the settled form of the Christian church,—and the use of the catacombs, the "cubicula" or crypts, in which were the principal cause of the use of crypts in churches. It appears that at first the Christians interred the dead in open fields, which were called "areæ," and we have the testimony of Tertullian, that when Hilarion was prefect the use of these "areæ sepulturarum" was denied to the Christians. "Let there be no areæ," was the decree. A similar expression is found in the Acts of St. Cyprian. Eusebius tells us, too, that their cemeteries were taken away from the early Christians, and not restored to them till the time of Gallienus, A.D. 262.* In fact, one part of the policy of the persecutor was to deny the rites of sepulture to his victims. According to Prudentius, the body of Hippolytus was cut into little pieces and scattered abroad. Many bodies were burnt, and the ashes given to the winds; many thrown into wells, and others into the sea. One of the most curious instances is cited by Baronius, in the Acts of the martyr Tharacus or Taracus. The Præsus Maximus, who seems to have resembled Judge Jeffereys in his violence of temper and language, burst out at the martyr—"Won't I destroy you? Yes! and, as I said before, even your remains. The little women shall not roll up *your* carcase in fine linen, and cover it with ointments and odours. No! I'll command you to be burnt, you scoundrel, and your ashes to be scattered to the winds." Under these trying circumstances, one tradition tells us, the Christians were compelled to flee to the crypts, or catacombs, both for the exercise of their worship and for the burial of the dead. Another tradition recorded by Baronius, states that the Christians, being condemned by their persecutors to labour in the mines like slaves, some of them were sent to these sand excavations, and took the opportunity to use them for the purposes before named.

Through the greater part of Italy, particularly round Rome and Naples, there are vast beds of an arenaceous substance, called "pozzolano." It is a very close and compact body of sand, mixed with a sort of burnt argillaceous matter in granules, very much resembling pounded brick, and is evidently of volcanic origin. Being the best possible material for making hydraulic mortar, it has been dug out in a countless number of excavations for ages; in fact the excavations are going on now. The material is very easily moved, and yet stands with extraordinary firmness; in truth, unless water has got amongst it, there is scarcely an instance of the roof or walls (so to speak) of an excavation falling in. It however varies much in hardness and quality, which probably accounts for the irregularity of the passages; the workman turning to the right or left, or ascending or descending, as the material was more or less easily worked, or more or less valuable. It also contains frequent masses of tufo, in which the cubicula or crypts proper are generally excavated.

The Romans called the pozzolano "arena," or sand, and the excavations "arenariæ," or sand-holes. Many of the Roman burial-places for depositing the "ollæ," or urns which contain the ashes of the dead, are excavated in this soil. But the most remarkable of all are these celebrated crypts in the catacombs near Rome. What are commonly called catacombs† are innumerable narrow passages tunnelled out in the solid earth, not more than 4 or 5 feet in width, and about 7 to 10 feet in height. Having been exavated without plan or settled purpose, they run in every conceivable direction—some side by side, some over each other, forming a most inextricable labyrinth—and that of such dimensions as to astound and bewilder the visitor. Aringhi has given several plans of parts of these; it will be seen on reference to his works they form mazes of passages, like the adits in a mine. The principal plans given by this writer are those called the Catacombs of St. Callistus, St. Agnes, and St. Marcellinus. In one plan, that of a small part of the former, it has been estimated there are full five miles in length of these adits. In the time of Baronius, forty-three of these cemeteries were known: at present it is probable twice the number have been found. Taken together it is estimated that there is a sort of network of these passages under Rome, which must measure at least 100 miles. In the sides or walls of these are a countless multitude of excavations, mostly about half a yard deep and about 6 ft. in length; in fact, square horizontal niches to hold the body—not of the pigeon-hole fashion of the Egpytians, but like bodies laid lengthwise, on a sort of shelves. Sometimes there is but one body in the height, sometimes two, three, and four, and in the catacomb of St. Saturnius are many places where no less than five bodies are deposited, one above the other in the height of the passage. The front is covered by a slab of stone, or very commonly of marble, and sometimes of terra-cotta, on which is usually carved the name and age and any other particulars of the deceased, and generally some Christian emblems. Some however are constructed by cutting a semicircular arch into the natural wall, and then sinking beneath it an excavation to receive the body, which is afterwards covered with a stone slab, and forms a tomb much like the monuments recessed into the walls of our cathedrals. These tomb tops have been used as altars. It has been reckoned that there are upwards of 170,000 bodies in the crypts of St. Sebastian only.

---

* The whole of this epistle of Dionysius of Alexandria to Hermammon is curious. The prefect Æmilian refuses to let the Christians make conventicula, or to "go (as they call them) to cemeteries." It is cited at length, Euseb. Hist. Eccl. vii. 11. The same author (ix. 2) tells us Maximin refused to allow the Christians to meet in churchyards.

† There has been a great deal of controversy on the derivation of this word. The earliest mention of it cited by Du Cange is in the 'Acta St. Sebastiani,' which he attributes to St. Ambrose or some other old author. "Hoc tu dum levaveris perduces ad catacumbas, et sepelies in initio cryptæ," &c. This passage is curious, as it shows the early distinction between the catacombs and crypts. Du Cange cites several other passages from various authors; among the rest a MS. of the Epistles of St. Gregory the Great (lib. iii. ep. 30), where *catatumbas* is read for catacumbas, and he supposes *cata tumbas* to mean ad tumbas, at the tombs, as one would say ad cryptas, ad valles. Probably this may be the right reading; for though we have not any similar word in a classic author, yet Valcknaer cites the word κατατυμβοχοεω in his annotations in the Idyll of Theocritus, "The Sicilian women going to see the Festival of Adonis." See Liddell and Scott, sub voce; See Valck. Adon. p. 324.

I know nothing more extraordinary than visiting these solemn places, which on the first occasion I did alone. It was at St. Sebastian. I had seen the noble church, and was then directed to a small door which opened, and there was a descent to the catacombs,—a narrow passage scarcely higher than one's head. At the entrance was a single bare-footed monk, in the coarse brown robe of his order. He lighted a torch, and we descended, proceeding by one winding turn after another, sometimes ascending and sometimes descending for a very long time. The atmosphere is close and stifling, and smelling of earth. Not a living thing, not an insect, not even a spider, is found therein. It is, in every sense, the abode of death.

Many stories have been related, and I can readily believe them, of persons who have ventured into these passages without proper guides, and who have been hopelessly lost. In fact, it is said that, as late as the year 1837, the teacher of a school, accompanied by thirty pupils, went into an excavation that happened to be open, stating that among so many it was impossible to lose their way; and that not one of the party was ever seen or heard of from the time of their entering, though every possible search was made by proper persons as soon as the fact was known. Other tales are related of those who have been so affected by the "gelidus horror" of their situation, the deep burial beneath the earth in an inextricable labyrinth, and in close contact with a vast multitude of the dead, as to become mad with terror. Nothing can describe these awful solitudes better than the words of St. Jerome, in his commentary on Ezekiel (cap. 40), who says, "When I was a boy at Rome (A.D. 350), and studied the liberal sciences, I was accustomed, with others of the same age and disposition, to go round on Sundays, and visit the sepulchres of the apostles and martyrs, and frequently to enter into the crypts, which are dug deep in the earth; and on each side of them, to those who enter, they have the bones of the dead for walls, and are so dark as almost to fulfil the saying of the prophet, 'Let them go down alive into hell.'"

Here and there are small chambers, commonly called "cubicula" or crypts proper, of the greatest interest. In them the primitive Christians are said to have assembled for a species of service, called by Tertullian (ad Uxor. i.), and by St. Cyprian (de Lapsis) συναξις, or gathering together; but this is simply impossible, as out of some fifty or sixty described by Aringhi, and of which he gives the dimensions, the largest is only 15 feet by 7½ ft. the greater part being only 9 or 10 palms (about 7½ ft.) square, while those lately discovered by Perret, and published by the French government, seldom exceed 4½ mètres each way. As has been said before, they are generally cut out of the solid tufo rock. The probability is they were oratories or mortuary chapels. That of St. Hermes, who is said to have been a prefect at Rome, who suffered martyrdom in the time of Hadrian, contains a tomb which is to this day occasionally used as an altar. It may be convenient to describe this crypt as the type of very many others. It is about 13 English feet in length, by about 6 ft. 6 in. in width, and about 8 feet in height, and arched like a barrel vault. It is approached by some steps leading out of one of the mazes of passages before described; it is plastered with a fine intonaco, and filled with paintings, as, in fact, a large majority are. The tomb at the end is, in fact, a sarcophagus; the top of which is plain, and the front is sculptured in three compartments. It is supposed there were two bodies buried at the end (besides that of the saint), four on the right side, and four on the left, besides three smaller spaces which probably held the bodies of children. In the centre a lamp has been suspended. This crypt of St. Hermes must not, however, be confounded with the church dedicated to that saint, which is of considerable size; and although now entirely covered over, apparently was originally only partly sunk in the earth, as there are a sort of clerestory windows, which gave light apparently through openings resembling the walls round the area windows of our houses.

Boldetti (pl. 2) gives a view of another crypt, which is in the catacombs of St. Agnese. It is groined, and on three sides has tombs, which have been used as altars. On one side is a large chair cut in the solid rock, said by him to have been an episcopal seat; by others the seat of a priest, while giving instructions to catechumens. Such chairs, however, are not uncommon in these crypts. In one given in Aringhi, vol. ii. p. 81, there are two similar chairs cut out of the solid tufo, and a bench of the same kind which goes round the other three sides of the room. It is said, but on what authority I do not know, that the second seat was for the deaconess, and used by her at the catechising or instructing the female converts. The crypt is, however, but 8 feet long, 7 ft. 6 in. wide, and 8 feet high, and has contained eight bodies, besides one (probably) over the door. In addition to those which have arched or groined roofs, there are some of which the ceilings are quite flat. The crypt called the Oratory of St. Helena is of this class; it is supported by four columns each, at a little distance from the wall. Sometimes the tombs were covered by a sort of grating carved in marble, through which visitors might look, and probably view the coffin of the martyr. A very curious one is found in the crypt of St. Calixtus. The grating is of peculiar form, and much like that under the altar at St. Nereo and Achilleo.*

It is the opinion of Seroux d'Agincourt, and seems a very probable conjecture, that the idea of these crypts was taken from a species of construction common among the Romans, where a "sacellum" containing an "ædiculum," or shrine to the tutelary god of the family, was erected over the "columbarium," or place for depositing the urns which contained the ashes of the different members of it. There is one which stands apart not far from the church of St. Agnes. It is wholly of brick, even the capitals of the columns being cut out of that material, and is supposed to be of the time of the early emperors. The shrine of the genius of the family is above, and below is an arched chamber, which was the sepulchre. On each of the four sides of this lower part is a niche, probably intended for the statues or "imagines" of its principal members, and eight other very small niches, each of which contained two urns full of the ashes of the dead. There can be but little doubt, that these Roman structures (which were a combination of the tomb and the oratory) gave the origin not only to the crypts of the ancient and mediæval church, but also to those picturesque tombs now so common in the cemeteries of Italy and France, where the family vault is below, and above is a little chapel, whose grated door displays an altar and crucifix, where the relatives repair at certain times to pray and to suspend crowns of "immortelles" in memory of the dead.†

It will not be within my limits to describe the various objects found in these crypts. The greater part contain paintings, some of very great merit; the subjects are mostly from Scripture history. There are also, as might be expected, many rings, coins, lamps, &c. found; plain chalices of mixed metal have also been discovered, probably eucharistic; strange and horrible instruments, supposed to have been used for the purposes of torture; phials of glass,‡ in which, it may be new to some to hear, are paintings. M. Perret is said to have made no less than eighty-six copies of paintings on, or rather in,§ glass in the various catacombs. To describe the symbols found on the tombs and the inscriptions would fill many volumes. They comprehend not only sepulchral inscriptions, the history and memory of the dead, pious ejaculations, religious emblems, but in many cases delineations of the instruments of the worldly calling or profession of the departed. There is one however of great interest to the architect, as forming probably the tomb of a mason or sculptor. There are represented the ordinary compasses, callipers, a rule, square, level, mallet, and chisels, and what is more curious, an instrument much resembling a trammel, and which has been surmised to be intended for the delineation of ellipses.

A few words however may be said as to the style and date of these crypts. In the admirable work of Seroux d'Agincourt a very curious parallel is given between the pictures found in the pagan tombs and those in the Christian crypts. The author is inclined to think they range in point of style and date from the second century to the eighth, and in instances at Naples even later. He gives as a parallel the paintings in a tomb discovered by Bartoli near Rome, which is clearly of the time of the Antonines, and those discovered in the crypt of St. Priscilla, which may be said to be identical in point of style.

---

* It resembles half-round tiles placed one over the other, but is cut out of solid marble.

† There are several in the Street of the Tombs at Pompeii.

‡ On the side of many of the tombs a small cup of glass is fixed, at the bottom of which is the remains of a dark substance, said to be the blood of the martyr there interred.

§ These representations appear to have been made on thin sheets of gold, the outlines being partly indented into the metal, which has then been blown into the bottom of the vessel between two thicknesses of glass.

That many of the paintings in the Christian crypts must be of very early date is also indicated by their still preserving some traces of pagan emblems. Thus the Muses still exemplify harmony; and for some time Orpheus* with his lyre, attracting the beasts around him, was given as an emblem of our Saviour. This is of frequent occurrence, and being surrounded by Scriptural subjects, as Daniel in the Lion's Den, Moses striking the Rock, the Raising of Lazarus, all prove them not to be the tombs of pagans but of Christians; and they also show how the memory of Orpheus was associated in their minds with the idea of the law-giver, the leader of civilisation; and, what is perhaps still stranger, to typify the inventor of fine art:* for it has been too much the case to represent the early Christians as stern ascetics, for whom poetry, music, art, and architecture had no charms.

Again, the whale swallowing Jonah is just in the style of the dragons on the walls at Pompeii, Elijah departs for heaven in a regular Classic quadriga; and the three kings seek the Saviour, each having on the Phrygian cap. On some are representations of persons dining together at a table, not reclining like Romans upon the lectum or bed around the triclinium, but seated in chairs. These we know, from the inscription αγαπη, written on them, must be representations of the "love feasts" of the early Christians. Another curious subject would lead us to believe that the Christians often employed heathen artists, for on one of the tombs the sculptor has probably forgotten and cut the usual pagan DM, or Diis Manibus; but has recollected himself and struck his chisel across the letters, and placed the well known Christian monogram by its side. These last cited circumstances, however, prove but little, as the αγαπαι were continued in churches as late as the sixth Council of Constantinople, commonly called the Council in Trullo, which was at the end of the seventh century; and if the tradition as regards the celebrated monogram be correct, the inscription alluded to must at least be of the time of Constantine. Of course, without direct evidence, it is difficult absolutely to pronounce on such a point; if however we may be allowed to reason from similarity in art, we may believe some of these crypts to be as old as the third if not the second century. The art, however, gives an idea of wealth and refinement among the early Christians, which we are usually taught not to expect at that period. It seems still more extraordinary that they should be permitted so to adorn their tombs. It must have been not only an expensive work, but one which must have taken up a great deal of time, and therefore could hardly have been done without the knowledge of the authorities. It must however be borne in mind, that the persecutions broke out at intervals,† and then ceased; and according to the worst accounts, the Christians had peace for more than 140 years out of the three first centuries.

If the internal evidences as to art give us no certain data, those as to architecture give us less. There are no distinctive marks about the construction of the passages, or the arching or groining of the crypts, that differ from what we know decidedly to be pagan work. It is true that the details of the capitals in the crypt at St. Agnes, before mentioned, seem to be Classic, but those in another of the same crypts (given by Perret in his magnificent book), seem very late indeed, and can hardly be called Classic work. Still more unlike are the caps of the crypt of St. Pretextatus, given in the same book, they certainly must be referred to a later period; while a corbel in the same crypt, discovered in 1846, is quite unlike anything Classic, but rather resembles Byzantine work.

My readers will remember the law of the Romans on extramural interments. It appears that frequent attempts were made from time to time, on the one hand to evade, and on the other to enforce it. Adrian passed a law fining any person 40 aurei (about £30) who buried a body in a city. Short as was the time between his reign and that of Antoninus Pius, we find that the latter was obliged to re-enact the same law, and that a few years afterwards Domitian was obliged to do the same. The consequence was, all the Christians, whether martyrs or not, were buried not only without the city, but also without the pomœrium or suburbs. Constantine seems to have been the first buried in a city. Eusebius says he was buried at Constantinople, in the Church of the Apostles; but St. Chrysostom says, "in the porch without the church, so they who wore diadems think it a favour to be buried so that kings are the fisherman's doorkeepers." It will be unnecessary to go through the history in all its points; it will suffice that the Council of Braga (A.D. 563) gave permission for men to be buried in the churchyard in cases of necessity (*si necesse est*), but on no account within the "walls of the church." The desire, however, to lay their bones under a holy roof grew so on men, that we find a Council at Mayence deciding that "no one should be buried in the church but bishops, abbots, or worthy priests, or faithful laymen;" and at last we find the Council of Meaux (Meldense) leaves it to the bishop and presbyter to settle who should be buried in churches and who should not. The result from that time to the present is well known.

When the persecution had ceased we naturally find the remains of those who had testified their faith with their blood held in greater reverence day by day. These tombs were first visited by those who dwelt near, and then became an object of pilgrimage to those who lived afar off. Pride of such a situation as the proximity of a holy grave in some, and the love of lucre in others, caused all sorts of pretences to be set up to the possession of a martyr's tomb or relics; and these, like all other possessions, soon became objects of barter or sale.

It is not my intention, nor would it be in place, to go into the history of the increasing reverence paid to the relics of the martyrs. It will be necessary however to mention that people were not content that the bodies of holy men should be venerated at their tombs, but a system of removing the relics into different churches now prevailed, which system was called "translation." The earliest mention I have found of this in the works of the ecclesiastical historians is in Socrates Scholasticus (lib. vii. cap. 25). He mentions a sect of Novatians who dug up the body of Sabbatius from the Isle of Rhodes, and conveyed it to Constantinople, and prayed on his tomb. Atticus, the bishop, however, caused the body to be removed (this must have been about A.D. 425). The same author (vii. 44) says that Proclus, about fifteen years later, removed the body of St. Chrysostom, who had been buried at Comana, to Constantinople, and laid it on the left side of the Church of the Apostles. But before this we have long accounts by St. Jerome, of the deposition of the bones of SS. Peter and Paul under the altars at Rome; of SS. Andrew, Luke, and Timothy; and Samuel, the Judge of Israel, at Constantinople. But we have no time to enter into details, which may be found in Baronius, and in the letters of the curious controversy between St. Jerome and Vigilantius. Suffice it to say that in almost every church relics of martyrs were deposited under the altars.*

This at first was done by simply making an opening under the altar, in which the bones or other relics were deposited, the front of which was closed by a sort of grating carved out of marble. It must be remembered that in the early basilican church the altar did not stand against the wall, but at the chord of the arc of the bema, or tribunal, on the edge of the raised platform itself; behind which, in the middle of the apsis and against the wall, was the θρονος, or seat of the bishop; and on each side of which were the seats of the presbyters, ranged in the form of a semicircle. To this day it is so in all churches which claim either to have been erected by the early Christians or re-erected on their foundations; and to this day in all such churches the priest says mass at the back of the altar, with his face towards the people, instead of the opposite method which is usual in other churches.

This place for depositing the relics was called the "confessione," or place where the relics of those who had *confessed* the faith are deposited, and this name is retained to the present day. The simplest and no doubt oldest form is that which was at the church of the Quattro Incoronati (before the alterations), and

---

[*] It is not impossible that the tradition of going down to Hades and returning again may have suggested a further parallel.

[†] The passages above cited from Eusebius seem to show that many of the persecutions were sudden outbursts of savage disposition, rather than a prolonged and organised series of cruelty and oppression like some of the later persecutions.

[*] Mabillon. Lit. Gall. (1, 9, 4), says no relics were placed *upon* altars till the tenth century.

which was a simple aperture under the altar, about 2 feet wide. Very much like this was that at SS. Nereo and Achilleo, which is closed by a curious grating, resembling in design very much that in the crypt of St. Calixtus, mentioned above. At St. Maria in Trastevere, the confessione is a sort of small chamber, about 5 ft. square, also under the altar. As time went on the confessione becomes larger, and more and more resembling the crypts in the Catacombs. At St. Maria in Dominica it is in reality a small crypt, about 13 feet by 10 feet, and is partly below the floor, and approached by a descent of five steps: in this is a sarcophagus, containing, it is said, the body of St. Ciriacus. At St. Prisca the crypt is still larger: it is a vaulted chamber, about 10 feet by 22 feet, the arch supported on two masses of masonry, strongly reminding us of the Etruscan tombs, behind which are two flights of stairs of about thirty steps in each. I must now call your attention to two confessiones, which partake more of the character of the passages of the Catacombs than of the crypts therein: one is that of St. Marco (A.D. 336, the pope, not the evangelist), this is a sort of passage-way, of semicircular form, the extreme diameter of which is about 24 feet—the passage itself is about 4 feet wide: it receives light from the grating under the altar. The other is at St. Prassede. Here the entrance is immediately under the altar, by a descent of eight or ten steps, leading to a passage about 40 feet long, which branches off into two semicircular passages, much like that at St. Marco: this must have been in existence in A.D. 499, in which year it was restored, we are told, by Pope Adrian, in a life of him written by Anastatius. A still larger crypt is at St. Martino: this was originally partly supported by a block of masonry, and partly on square pillars, like the Etruscan tombs, and forms in fact a small church, about 45 feet each way. In fact, this is the form the crypt now began to assume. At St. Maria in Cosmedin it has a nave and side aisles, formed partly by six columns, three on each side, and partly by two solid blocks of masonry, and is about 22 feet by 13 feet. At St. Lorenzo it is still longer, about 30 feet by 16 feet, and has four columns on each side, and also a tomb in the centre.

I have thus shown that, as time progressed, the small aperture called the confessione had increased till it became larger and larger, till at St. Miniato near Florence, and St. Michele at Pavia, it had lengthened to 60 feet and upwards, and become a second church.

In this country there are several crypts which I believe to be of the Saxon era,—plain groined chambers, with four columns at the angles. In the Norman era the crypts increased in size, and afterwards were larger and larger, till very many of them were co-extensive with the choir of the church. The Early English crypts were very fine and interesting, and of those may be mentioned that at Rochester Cathedral, and, what must have been a still finer example, the crypt under old St. Paul's, which formed a church by itself, and was very nearly half as large as the entire edifice. Here however we must stop; for just at the origin of the Decorated style of architecture, when there were no differences on points of religion, nor any cause whatever in the church to account for it, crypts proper suddenly ceased to be constructed, with the exception of some small ones occasionally under a chapter-house or a transept. The Early Decorated, the Later Decorated, and the Perpendicular periods presented no instance of a crypt under the choir of any large church or cathedral; at all events, neither Mr. Scott, Mr. J. H. Parker, or other friends whom I have consulted, could cite any example of the kind. This was the more remarkable, because when crypts beneath churches fell into disuse, they became common under secular buildings. Thus, there was a large one of Perpendicular character under the Guildhall, London, and another under Gerard's Hall; but at present no reason had been assigned for their discontinuance under churches.

Dr. Biattoblotzky adverted to the crypts or catacombs at Naples, Alexandria, and Paris, as analogous to those of Rome. Those at Alexandria he had seen opened, and had witnessed their wanton destruction by gunpowder, from the eagerness of the Turks to obtain the sarcophagi, which were mostly of alabaster, in order to convert them into lime; a species of destruction against which the Institute might do well to raise its powerful voice. The sculptures in those catacombs presented a similar admixture of pagan and Christian subjects with those of Rome. The catacombs under Paris were very interesting, but under the pretence that various persons had been lost in their intricate mazes, and never found again, it was now difficult to gain access to them; but it would be very desirable if permission could be obtained for the members of the Institute to explore them, with a view to confirm the remarks of Mr. Ashpitel. The tombs of the kings at Jerusalem were also exceedingly interesting in connection with the subject under consideration.

Mr. Kerr called attention to the question of the degree of art displayed by the early Christians in the sculpture on their tombs, these being the only works by which the question of their artistic knowledge and feeling could be determined. He believed that public opinion was right, and that the opinion of Mr. Ashpitel was wrong, inasmuch as there was a total absence of artistic feeling throughout the earliest of these works. It would appear that the early Christians repudiated and discouraged art, and indeed destroyed it wherever they could find it.

Mr. Ashpitel said, it had been his intention simply to confine himself to the collection of all the facts relative to crypts, and this rather as applied to their architecture than their artistic features. It was impossible however, in spite of any popular ideas or preconceived notions, to shut the eyes to the fact, that in hundreds of crypts which had been explored, and probably in thousands which had not been visited for many centuries, there was, he could almost say a lavish expenditure of fine art of a very high order for the time; but it was not only so, the tombs of the poor class also showed some taste for decoration. The digger, or "fossor," was sculptured in his tomb with his spade and mattock as he stood in life: the carpenter and mason had the tools of their trades carved in the same way. Sometimes the whole-length figure and sometimes the bust only of the "honesta conjunx" was sculptured on the slab which inclosed her remains; and, if nothing else, two rudely carved doves, or a dove and a heart, attested the affection that had subsisted between the departed. One main fact is certain, they are all tombs of Christians. The heathens at that time almost universally burned their dead; but apart from this, the inscription, the symbols, and above all the numerous pictorial subjects taken from the Old and New Testaments, proved the religion of the deceased. It might now be inquired, of what rank was that art, and about what period was it executed? The art in its general scope strongly resembled that in the Baths and Palaces of Titus, and of the Antonines. The ceilings are vaulted, and as well as the walls are panelled out in elegant designs in stucco. The great work of Aringhi, as well as of others who have succeeded him, give a very good idea of the costly and elaborate nature of the general design, but they are of too small a scale to afford an adequate notion of the power of the artist. This difficulty has now been obviated by the publication by the French government of the magnificent work of M. Perret. This gentleman had devoted six years to the study of art in the crypts and catacombs. The part already published fills six large volumes of atlas folio; and certainly in a great number of the examples the drawing and colouring contained therein rank very high—if not first, in the very first line. With regard to the period at which they were executed, he could only again refer to the authority of Seroux d'Agincourt, who considers some as old as the second century. Mr. Ashpitel considered that any stranger brought into these crypts for the first time would say, These are the tombs of an art-loving people. Although we know that in other countries the conversion first began among shepherds and fishermen, yet at Rome the Apostle was a man of high intellectual acquirements; and the tradition attached to the history of the basilica would show that among the early Roman Christians were many of the exalted and noble. Be that as it may, they had a very striking fact before them, and one which deserved the most serious consideration.

ARSENIC IN PAPER-HANGINGS.*

By H. Letheby, M.B., M.A.

About three years ago public attention was directed to a circumstance well known to men of science, that a large proportion of the arsenic sold in this country was used in the manufacture of a green pigment for paper-hangings. This fact was mentioned, on the authority of Dr. Taylor, in the *Times* newspaper of the 6th of January, 1858, and it forthwith excited a very warm discussion. On the one hand, manufacturers declared that as arsenical pigments were not in themselves volatile, and were moreover fixed to the paper by adhesive materials, they could not evaporate so as to infect the atmosphere of rooms, and be a source of danger. In support of this statement there was the testimony of chemists, founded on actual experiment, namely, that arsenic could not be volatilised from paper at any ordinary temperature, and that it could not be detected in the atmosphere of rooms covered with arsenical papers. But on the other hand, there were the observations and experience of medical men, not merely in respect of the poisonous action of mineral green on those who are engaged in its manufacture, but also of the effects of the pigment on those who are occupied in handling green paper, and who are exposed to its influence in rooms covered with it. All of which went to show that something is evolved from the pigment capable of producing the same class of effects as those which result from the operation of arsenic—namely, headache, dryness of the throat and tongue, nausea, irritation of the alimentary canal, great bodily depression, and various nervous disorders. Further investigation led to the discovery of arsenic in the dust of rooms covered with such paper, thus proving that although the arsenical pigment was not volatile in a chemical sense, yet it became detached from the surface of the paper, and was easily diffused through the atmosphere of the room. Still, as no actual or undoubted case of poisoning had been clearly traced to it, it was well enough argued that all the effects attributed to arsenical paper might have arisen from other causes. At last however the mischief has been followed to its source. A fatal case of poisoning by such paper has been the subject of medical investigation. The case is described by Dr. Metcalf, in the *Lancet* of December 1, 1860, page 535, and as the chemical part of the investigation has been in my hands I here offer a brief outline of it.

---

* From the Journal of the Society of Arts.

Clarence W. King, the son of Mr. W. T. King, of Beresford-lodge, Highbury, a child aged three-and-a-half years, was taken unwell during the morning of November 1. He complained of chilliness, and was sick. At ten o'clock in the morning he was attacked with convulsions, and at eleven o'clock he was seen by Dr. Metcalf, who found him in a semi-comatose state. On the following day, at seven o'clock in the morning, Dr. Metcalf was summoned to see another child, a sister, aged two-and-a-half, who had been violently convulsed. At that time the little boy had become worse: he was almost in a state of asphyxia; the surface of the body was cold, the pulse feeble, and the countenance livid. By the use of appropriate remedies he was somewhat relieved, but in the afternoon of the same day he was seized with violent tetanic convulsions; and from that time there were alternations of repose and convulsive action until he died: this occurred thirty-eight hours after the commencement of the attack. At first Dr. Metcalf did not suspect the real cause of the mischief, but when the second child was attacked it occurred to him that the effects in both cases were due to the same cause, and were not the results of natural disease. His suspicions were further aroused by the circumstance, that three months previously the children had been attacked in a similar manner, and had recovered after leaving the house for the sea-side. On inquiry he was told that they had, within the last few days, been playing with toys that were kept in the cupboard of a room lined with green paper; and that a day or two previously they had been amused by helping to clear out the cupboard, and that the little boy had been observed to suck a piece of lace which was found there. A large portion of the paper was at once removed, and sent to me for examination. I found that it was an arsenical paper, containing nearly fifty-two grains of arsenite of copper on a square foot, and the pigment was so loosely attached to the paper that it was removed by the slightest friction. The dust from about 5 square inches of the paper was capable of producing all the symptoms observed in the boy, and the pigment from a piece 6 inches square would have sufficed for the death of two adult persons.

On the following day the child's body was examined, and the organs found free from natural disease. The stomach and part of the liver were sent to me for analysis, and the results were the discovery of arsenic and copper in both these organs. So clear was the entire history of the case—as the previous attack, the symptoms of arsenical poisoning, the simultaneous effects in both children, the discovery of the poison in the dead body, and the existence of arsenic and copper in such profusion on the paper of the cupboard—that the coroner's jury had no hesitation in returning a verdict that death had been caused by arsenic derived from the paper; and they added that the manufacturer had been guilty of very careless and culpable conduct.

In the course of the last year or two I have had referred to me many cases of suspected poisoning by green paper, and on examining the paper have invariably noticed that in such cases the arsenical pigment is but loosely attached to the paper; and no doubt the effects have been produced by the mechanical removal of the pigment, and the diffusion of it through the atmosphere of the room. It is very probable that this effect is due in a great degree to the heat and the acid product of burning gas; for it has been frequently noticed that the poisonous action of the pigment is most clearly manifested in rooms lighted with gas. This may arise from the sulphurous acid formed during the combustion of the gas, fixing itself within the porous texture of the paper, and becoming sulphuric acid, which soon destroys the adhesive matter that holds the pigment to the surface of the paper, and then the colour is easily brushed off.

All green papers are not equally poisonous, for as the shades of tint are produced by mixing carbonate of lime or chalk with the arsenical green, the proportion of arsenic may vary from a mere trace to many grains on a square inch of paper. The largest quantity which I have ever found has been in the proportion of 59 grains on a square foot. A piece of this paper 3½ inches square has enough arsenic upon it to destroy human life. As far as my investigations have gone the flock never contains arsenic, but is dyed with comparatively inert materials. It is the ground of the paper which is so dangerous; and here I may mention that any green paper which gives a deep blue solution when it is steeped in liquid ammonia is suspicious, for it then contains copper, and in all probability arsenic likewise.

◆

A METHOD OF TAKING OFF THE WASTE GASES FROM BLAST FURNACES.

By Charles Cochrane, Middlesborough.

(*With an Engraving.*)

There is no novelty in the fact of taking off the waste gases from a blast furnace; for many methods have been and are at present employed for accomplishing this object. Though the writer was unaware of any similar method, it is not desired to claim originality in that about to be described; but as there is such acknowledged diversity of opinion as to the respective merits of different plans, and great difficulty in procuring reliable information on any, it is proposed to give a description of an arrangement which has been in successful operation for some months at the Ormesby Iron Works, Middlesborough, and bids fair to realise the best expectations of its merits. The large waste of fuel from the mouth of a blast furnace where the escaping gases are allowed to burn away is well known, and amounts to more than 50 per cent. of the fuel burnt; hence there is considerable margin for economy, bearing in mind the large quantity of coals consumed in raising steam for generating the blast, and the further quantity necessary to heat that blast to the required temperature. In fact, assuming a consumption of 300 tons of coke per week to make 200 tons of iron, about 100 tons of coals would be required to generate steam and heat the blast. Taking off the gases from one furnace under such conditions does, according to actual experiment, furnish gas equivalent to upwards of 150 tons of coals per week. This is obviously an important matter where coals are expensive.

The blast furnace is alternately charged with coke, ironstone, and limestone, in proportions depending upon the quality or "number" of iron desired. The arrangement of these materials in the furnace is generally deemed important, though it admits of considerable latitude without any appreciable alteration in the working of the furnace. Thus it does not seem to be of any importance whether the charge of coke be 12 cwt. or 24 cwt., the amount of load of ironstone and limestone being in the same proportion of 1 to 2. The chief point, if there be one, to be gained in the arrangement of the material is to distribute it pretty equally over the furnace, not allowing all the large material to roll outwards and the small to occupy the centre of the furnace or *vice versâ:* for it is supposed the ascending gases will pass through the more open material of the furnace to the injury of the closer; thus the two reach the active region of reduction in different states of preparation, and the operations of the furnace are interfered with. To provide for this contingency,

---

[*] From a paper read at the Institution of Mechanical Engineers.

COCHRANE'S BLAST-FURNACE WASTE GASES

Fig. 1.

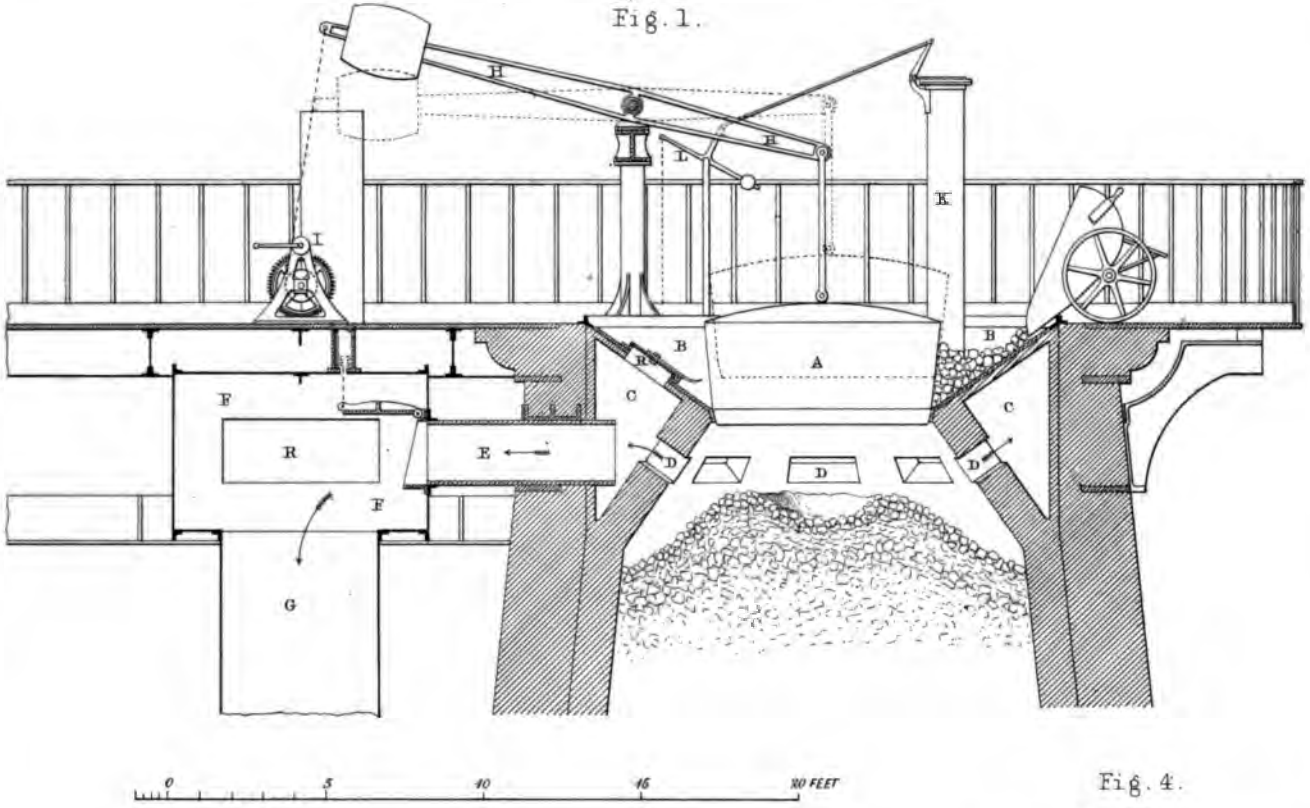


Fig. 2.

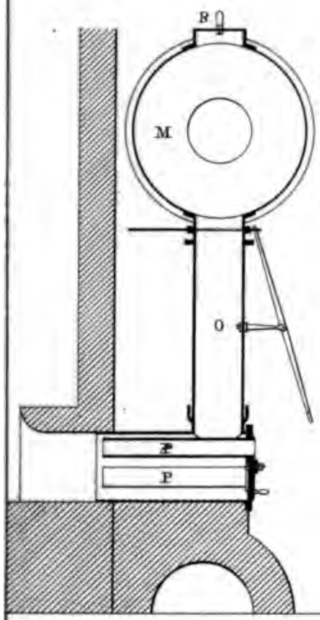


Fig. 3.

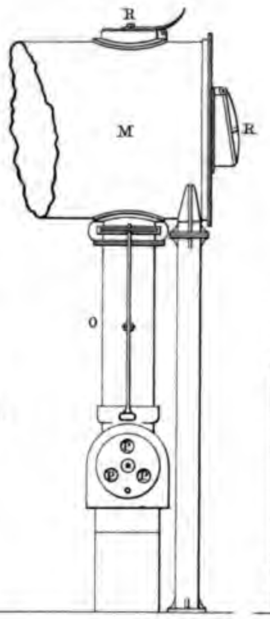
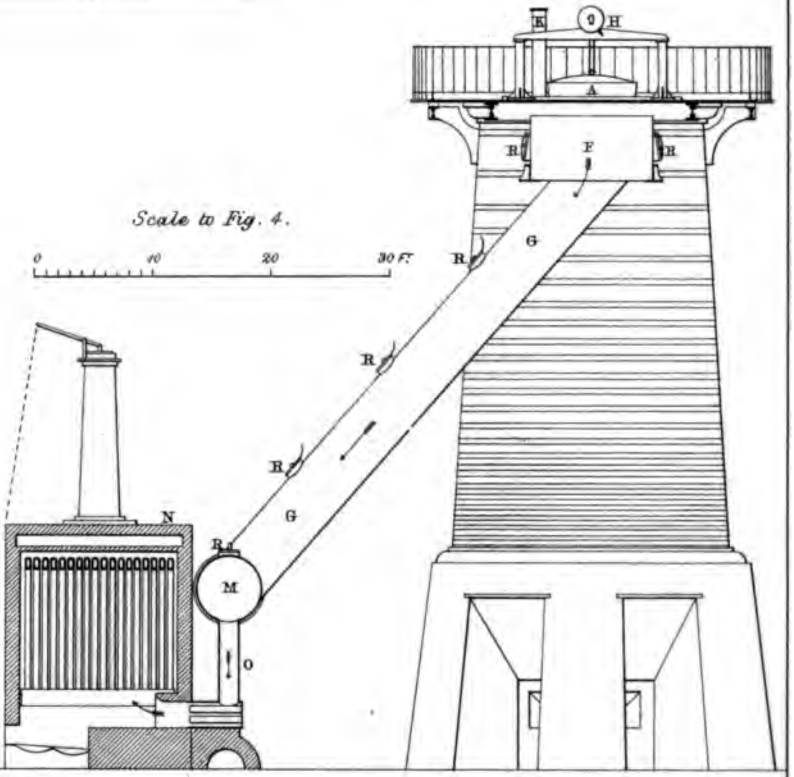


Fig. 4.



Jan^y 1861

J.R.Jobbins.

which is met in an open-topped furnace by filling at the sides at three, four, or even six points of the circumference of the throat, allowing the material to slide inwards 2 or 3 feet on a sloping plate, it was considered expedient in the present instance to make the filling aperture as large as practicable; it was therefore made 6 ft. 6 in. diameter, as shown in Fig. 1, so that the material tends to arrange itself in a circle a little outside the centre, thus correcting the tendency of large material to roll outwards by causing a similar tendency to roll towards the centre also. This point is gained in one of the simplest methods in use for closing the top of a blast furnace, where a cone is used to lower into the furnace for filling; but it is secured at the expense of the height of material in the furnace. A certain height is necessary for the efficient working of the furnace, and if this be diminished it must be at the expense of fuel in the furnace, since the absorption of heat from the gases depends on the height of material through which they have to pass up: if this be diminished, the gases issuing from the throat of the furnace will escape at a higher temperature; if increased, at a lower.

But there is an important difference to consider in the conditions of a closed and an open-topped furnace, to which the writer is not aware that attention has hitherto been drawn; a difference which acts somewhat in favour of the open-topped furnace. The working of the furnaces themselves seems to show that an open-topped furnace is less sensitive to irregularities of moisture in the material, quantity of limestone, size of material, &c.; which can be accounted for only by the fact that the open-topped furnace has the advantage of a large amount of surplus heat due to the combustion of the waste gases at its throat, which serves to dispel moisture and calcine the limestone, and helps to warm up the large pieces of ironstone: all of which operations in the close-topped furnace are effected only at a lower point of the furnace, thus necessitating a larger consumption of coke. With the same proportion of ironstone to limestone it has been found to require about 10 per cent. more fuel to produce the same number or quality of iron in a close-top than in an open-topped furnace. In the close-topped furnace the gases pass away at a temperature of about 450° Fahr.; whilst in the open-topped a temperature of between 1000° and 2000° is generated in the throat of the furnace by their combustion.

In comparing the extra quantity of coke consumed in a close-topped blast furnace with the saving in coals for the boilers and hot-blast stoves, it is obvious that the economy to be derived by taking the gases off depends on the comparative value of coke and coal. In the Middlesborough district, where coal is expensive, it is an undoubted source of economy; where coke is very dear however, and small coal can be obtained at a mere nominal cost for boiler and stove purposes, the use of the waste gases would possibly do little more than compensate for the outlay involved. Here, no doubt, is one source of the variety of opinion entertained in various districts as to the advantage of taking off the gas. The writer's experience at Middlesborough has been that the waste gases can be taken off without affecting the quality of the iron produced, though at the expense of more fuel.

The mode of closing the furnace top and taking off the gases at the writer's works is shown in Fig. 1. The top of the furnace is closed by a light circular wrought-iron valve A, 6 ft. 6 in. diameter, with sides tapering slightly outwards from below, to admit of being easily drawn up through the materials, which are tipped at each charge into the external space B. To prevent excessive wear upon the body of the valve, shield plates are attached at four points of its circumference, against which the material strikes as it rolls out of the barrows. An annular chamber C encircles the throat, triangular in section, into which the gas pours through the eight orifices D D from the interior of the furnace, and thence passes along the rectangular tube E into the chamber F. At the extremity of the tube E is placed an ordinary flap valve opened by a chain, by means of which the communication between the furnace and the descending gas-main G, may be closed. The valve A, is partially counterpoised by the balance weight at the other extremity of the lever H, and is opened by a winch I, when the space B is sufficiently full of materials. At the time when the blast is shut off for tapping the furnace, the gas escapes direct into the atmosphere through the ventilating tube K, which is connected by levers L with the blast inlet-valve below.

Fig. 4, shows the connection between the furnace top and the hot-blast stoves to be heated by the waste gases, which pass down the descending main G into the horizontal main M running parallel and close to the line of stoves N, from which descend smaller pipes O to each stove, as shown in Figs. 2 and 3. The supply of air for burning the gas in the stoves is admitted through the three tubes P, and can be regulated at pleasure by the circular slide closing the ends of the tubes, which has an aperture corresponding to each tube, and is planed on the rubbing face, as is also the surface against which it works, in order that the slide may be sufficiently air-tight when closed. The ignition takes place where the air and gas meet, the ignited gas streaming into the stove and diffusing its heat uniformly over the interior. An important element in the working of an apparatus of this description is to provide for explosions, which must take place if a mixture of gas and air in certain proportions is ignited. To provide for this contingency, escape valves R are placed at the ends and along the tops of the main tubes G and M: but to prevent explosions as far as possible, the ventilating tube K, Fig. 1, is used at the top of the furnace, connected with the blast valve at the bottom, so that when the valve is closed, as at casting time, the act of closing opens the ventilating tube and allows the gas to pass away direct into the atmosphere. The gas would otherwise be in danger of slowly mixing with air passing back through the stoves or otherwise gaining access into the tubes, and would thus give rise to an explosion; until the ventilating tube was provided it was necessary to lift the valve A closing the mouth of the furnace when the blast was taken off, otherwise slight explosions took place from time to time.

In the use of Durham cokes in the blast furnace an inconvenience arises from the large deposit which takes place in the passage of the gas from the furnace, and in the stoves and boilers. Under the boilers this deposit is a great objection, as it is a very bad conductor of heat, and needs to be frequently removed: in the stoves it is not so objectionable, though these need a periodical cleansing. The deposit does not arise altogether from the cokes, it is true; and it may be interesting to know its composition, which is as follows:—

Silica	18·86
Carbon	16·14
Alumina	13·87
Sulphate of lime	13·61
Lime	11·01
Protoxide of zinc	10·31
Peroxide of iron	9·01
Protoxide of manganese	2·56
Potash	2·13
Protoxide of iron	1·25
Magnesia	1·25
Chloride of sodium	0·60
	100·60

At a temperature of upwards of 3000° this mixture melts in a yellowish slag, dispelling the zinc; but there are no signs of fusion at the temperature produced by the ignition of the gas in the stoves, which must roughly approximate to that of melting iron from the results of a few experiments made to ascertain this point: though thin pieces of cast-iron were not fairly melted down, they reached the rotten temperature, which is only a few degrees below melting, and gave further signs of nearly melting by throwing off sparks when quickly withdrawn from the stoves and struck smartly against another object.

The writer has heard it asserted that the closing of the top of the furnace is the source of mischief to its working by producing a back pressure in it. Under ordinary circumstances, with the furnace top open, the blast enters the tuyeres at a pressure ranging from 2½ to 3 lb. per square inch. In the present close-topped furnace there are eight outlet orifices D, Fig. 1, each 2 feet by 1 foot, giving a total area of 16 square feet for the passage of between 5000 or 6000 cubic feet of gas per minute raised to a temperature of 450° Fahr.; and the actual back pressure of the gas as measured by a water gauge inserted into the closed top of furnace is from ½ to ⅝ inch column of water, or about 1-40th or 1-50th of a pound per square inch, an amount so trivial as compared with a pressure of from 2½ to 3 lb. as to be unworthy of notice. Of course if the tubes are contracted in size a greater back pressure will be produced; and it is quite possible that, where attention has not been paid to the circumstance, the back pressure may have interfered with the working of the furnace by preventing the blast entering so freely.

As regards economy in the wear and tear of hot-blast stoves of the ordinary construction, there can be no question the pipes last much longer when heated by gas, provided the temperature of the stove be carefully watched to prevent its rising too high; whilst the value of the same heating surface compared with its value when coals are used is greatly increased, owing to the uniform distribution of the ignited gases throughout the stove: in the use of the gases at the writer's work, this economy of surface is such that two stoves heated by gas will do the work of little more than three heated by coal fires.

In the course of the discussion upon the paper—

Mr. W. Mathews said that he considered the subject of economising the waste gases from blast furnaces was one of much importance, and asked whether there was found to be any material difference in the working of the close-topped furnace, and whether the closing of the top for the purpose of taking off the gases interfered with the burden of the furnace or the quality of iron produced. If the quality and yield of iron were not disturbed, the utilisation of the waste gases must be a source of economy where fuel was dear; but otherwise, where coals were cheap, it might hardly be worth while putting up an apparatus for taking off the gases. In the case of some blast furnaces lately erected at Heyford in Northamptonshire, where the ore was cheap but coal expensive, costing 14*s.* or 15*s.* per ton at the furnaces, the iron could not have been worked profitably unless the waste gases were taken off, this had accordingly been done, and he understood had proved thoroughly successful, reducing greatly the cost of making the iron. It seemed remarkable that the use of the waste gases was not yet adopted in South Staffordshire; but this was no doubt owing to the extreme cheapness of small coal throughout the district, as compared with the North of England, so that it might not be economical to take off the gases. At Dundyvan, in Scotland, a method had been employed some years ago for taking off the gases without closing the top of the furnace, and the gases were used for the hot-blast ovens and engine boilers; but the heat obtained was very irregular, sometimes high and sometimes low, causing much difficulty in keeping up the temperature of the blast and in getting the required supply of steam; and he understood the plan had recently been discontinued there on account of the trouble experienced in its use.

Mr. C. Cochrane replied that the regularity of the furnace was certainly interfered with, though only to a slight extent, by closing the top, and the furnace was rendered more sensitive. In the first trials of the close-topped furnace mottled iron was made frequently, and occasionally white iron; but by exercising sufficient care in managing the furnace the irregularities were now in a great measure got over. During the last six months his furnace had worked with only 7 per cent. irregularity altogether, and this was now reduced to 5 per cent., estimating the amount of irregularity by the proportion of mottled iron made instead of grey. Where it would be an objection to make mottled or white iron occasionally, it would not be advisable to try taking off the gases; and coals were so cheap in South Staffordshire that it might not be worth while to run the risk of getting white iron, as it was of more importance there to make all grey iron than in the Middlesborough district, where there was a great demand for forge iron.

Mr. C. Markham had been connected with some blast furnaces at Marquise in the North of France, fourteen years ago, from which the waste gases were taken off very successfully; and thought the mode of carrying out the plan in that case was superior, owing to the gases being conveyed upwards to a higher level to be burnt, as they would naturally rise by reason of their specific gravity being less than that of the atmosphere. There were two furnaces built side by side against a bank, and the gases were taken off about 5 or 6 feet below the top by a circular flue running all round the furnace; they were taken under six Cornish boilers situated at the top of the bank, a few feet above the top of the furnace. The gases were drawn off from the furnaces by a chimney 90 feet high, and they frequently produced a large flame from the top of the chimney. The evil of the gases firing subsequently to passing under the boilers was removed to a considerable extent by the erection of an additional flue, which caused the gases to be more perfectly mixed with air, and fired before they were cooled down by coming in contact with the boilers. The regular make of each furnace was 100 to 120 tons of cold-blast iron per week, and the consumption of coke was about 1½ ton per ton of iron made. The coke cost 30*s.* per ton, so that economy of fuel was of great importance; the boilers were worked entirely by the waste gases from the furnaces. At these furnaces they had tried at first bringing the gases downwards to the boilers at a lower level, but the success was very imperfect; and this appeared to him the reason why the waste gases had not been taken off so successfully at some works in this country, as they had in every case he believed been conveyed downwards from the top of the furnace instead of upwards, and also the height of the furnace had not been increased to compensate for the gases being taken off at a lower level. He had seen the application of the gas at the Clay Cross and Alfreton furnaces in Derbyshire; and had no doubt an economy was effected in the cost of the iron made: at these works however the gas was applied only for heating the hot-blast stoves, but the quantity required to heat the blast was small as compared with that required to raise a sufficient supply of steam for working the blast engine.

Mr. C. Cochrane said no difficulty had been experienced in bringing the gases down, and the vacuum required was found by actual measurement to be only ½ to ⅝ inch column of water, or 1-40th of a pound per square inch, which was not sufficient to produce any injurious effect on the working of the furnace.

Mr. C. W. Siemens had seen furnaces working at Charleroi, in Belgium, where the gases were drawn down from the top of the furnace without any difficulty, by means of a pipe inserted in the side of the furnace near the top; but it was found necessary to allow at least one-third of the gases to burn out of the mouth of the furnace, otherwise the working of the furnace was interfered with, and neither was the iron of such good quality nor the gas so effective for heating purposes. In the close-topped furnace at Middlesborough described in the paper, he suggested whether any difference of make or irregularity of working was not rather to be attributed to imperfect distribution of the materials in charging, than to closing the top: with a closed top and an arrangement for filling in the centre, as shown in the illustrations, there was no means of filling at the sides of the furnace, and the materials might roll sometimes more to one side than the other, producing a greater draught through the furnace in one direction, so that the ore would arrive at the point of reduction in different states of preparation, which would interfere with the quality of iron made. A slight difference was sufficient to direct the flame and current of gas in a blast furnace more to one side than another: even in drawing off the gases by a circular chamber all round the furnace, the draught-holes on the side nearest the main flue would draw more than those on the opposite side; but this might be obviated by making the holes nearest the flue of a smaller size.

Mr. S. Lloyd said they had now adopted a plan for taking off the waste gases at the Old Park furnaces, and had had it working there successfully for some weeks, without any injury being caused to the working of the furnace; the iron seemed if anything to be rather better in quality, a little more grey and somewhat increased in quantity. The plan was that of Mr. Darby, of Brymbo in North Wales, where it had been at work successfully for two years past; it consisted of a plain upright tube inserted into the centre of the open mouth of the furnace, and then carried over down the outside of the furnace, where the gas was burned under the steam boilers, the flues of which were connected with a sufficiently tall chimney to produce a draught for drawing down the gas. The large area between the tube of 5 feet diameter and the mouth of the furnace of 10 feet diameter was left open, so that there was no pressure on the furnace, which worked in that respect exactly like an open-topped furnace. The tube was inserted about 5 feet deep into the materials at the top of the furnace, and by this means they got four boilers heated by gas without any cost for fuel. He thought this plan of leaving a large portion of the furnace top open was the only practicable way of taking off the waste gases in the South Staffordshire district, where it was of the first importance that grey iron should be made, and considered it was a great improvement on the close-topped system: for the open top of the furnace allowed the extra quantity of gas to escape direct into the atmosphere; but with a closed top the top of the furnace was choked, and the accumulation of gas was liable to produce a back pressure on the furnace, which they had found by experience was very injurious.

Mr. E. A. **Cowper** had seen the furnace at the Ormesby Works, and thought the arrangement there employed for filling produced a good distribution of the materials. The plan of closing the furnace top by a cast-iron cone or bell inside the furnace, fitting up against a cast-iron ring or seat, was a good arrangement when properly carried out as at Ebbw Vale; though in some cases, where the cone had not been properly proportioned to the size of the furnace, an unequal distribution of the materials took place, the smaller pieces lying in a heap in the centre, while the larger ones rolled down to the sides of the furnace, causing a stronger draught up the sides than at the centre; and in large-topped furnaces where the charging cone was of small size, the sides thus became much hotter than the middle of the furnace. But in the arrangement shown in the illustrations this difficulty was got over by making the charging opening not less than half the diameter of the top of the furnace, the effect of which was that the larger pieces now rolled towards the centre as well as the sides, so that there was as strong a draught up the centre as at the sides, and the heat was rendered more uniform. He believed that the regular working of a furnace depended quite as much upon the materials being nearly of a uniform small size as on anything else, and that sufficient attention was not generally given to this point. The simple fact of closing the top of a furnace or leaving it open could not he thought cause any appreciable difference in the working of the furnace; for the ordinary pressure of the atmosphere on an open-topped furnace varied far more than the increase of pressure caused by closing the top and drawing off the gas by the draught of a chimney, as this was shown to amount to only ½-inch column of water, or only $\frac{1}{24}$-inch rise of the barometer. If a closed top were inadmissible for a furnace from some other cause, then such a plan as Mr. Darby's might be adopted for taking off a portion of the gas; but a high chimney would be necessary to draw the gas off through the tube, and care must be taken to keep the mouth of the tube always covered up for some depth by the material in the furnace, to prevent the risk of drawing in atmospheric air; the tube would he thought be troublesome to keep in repair on account of the great heat to which it was exposed, and with its end buried 5 feet deep in the material would not last many weeks.

Mr. A. B. **Cochrane** was glad to hear of an instance of the waste gases being taken off successfully in the South Staffordshire district, as their use would effect an important saving of fuel for the steam-boilers and hot-blast ovens, if it could be satisfactorily carried out; for though at present there was an abundance of cheap small coal, it had been pointed out that the time was drawing near when the thick coal would be exhausted in the parts now worked, and it was therefore as necessary to economise the consumption in that district as in the North of England. He hoped the plan that had been referred to would be described more fully, with the results obtained as to cost and economy of fuel, that it might be satisfactorily determined whether such a method was applicable without injury to the quality of iron made.

Mr. E. A. **Cowper**, in reply to a question, said that the gases could be carried a great distance, several hundred yards even, before being burnt, as the slight pressure in the top of the furnace was quite sufficient. When taken off from a close-topped furnace, they came off at the comparatively low temperature of 400°, and would lose only 50° to 100° within moderate distances.

Mr. **Sampson Lloyd** had tried the plan of taking off the gases by a closed top and charging cone several years ago at the Old Park furnaces, on the method adopted in South Wales that had been mentioned, but it was finally abandoned, as the furnace could not be got to work satisfactorily; and they were about to take down the pipes used for conveying away the gases, when he heard of the plan employed at the Brymbo Works, which seemed fully to meet the difficulty of avoiding any interference with the working of the furnace, and an apparatus of that kind was accordingly put up. They had several difficulties to encounter in the first attempts at getting the plan to work; and the end of the tube was melted off in consequence of reaching too far down into the hot part of the furnace. But all objections seemed now to have been got over, and they had had the plan at work nearly a month with most satisfactory results: the furnace worked better, and brought down the iron more quickly; it only required a little management when standing, to prevent the portion of the tube in the furnace getting injured.

Mr. C. **Markham** observed that there must still be a great waste of gas escaping through the open space round the centre tube, when the top of the furnace was not entirely closed. Even in close-topped furnaces fitted with a cone a considerable leakage of gas took place round the joint of the cone, and when the furnace was being charged; and in the arrangement shown in the drawing he thought the leakage at the joint would be much increased by the large diameter of the top valve.

Mr. E. A. **Cowper** said the valve had a very good joint, as it was made with a cast-iron rim at the bottom, having a spherical bearing surface, so as to drop always fairly into its seat like a ball-valve, and the seat was a strong cast-iron ring, to insure keeping its shape; the valve closed remarkably tight when lowered into its seat, scarcely a trace of leakage being perceptible at the joint.

Mr. T. **Snowdon** thought in working with close-topped furnaces for taking off the gases, a great deal depended on having a sufficient height of chimney to insure drawing off the gas with regularity; if the chimney were only as high as the furnace, the two columns of gas would balance each other and there would be no power of draught. The draught required however seemed to vary much in different furnaces; for in the Clay Lane furnaces at Eston near Middlesborough, the chimney was only a few feet above the top of the furnace, but produced quite draught enough, while he had seen other furnaces with higher chimneys that were not working well. At his own furnaces at Middlesborough he would have preferred placing the boilers and hot-blast stoves at the top of the furnace if it could have been done, in order to take the gases direct to them; but this was not practicable, and the gases were therefore drawn down from the top of the furnace by a chimney 120 feet high and 8 feet square, having 64 square feet area of draught. The temperature and nature of the gases taken off depended greatly on the burden of the furnace, according to the quality of ironstone that was being worked; with a heavy charge of limestone the gas would not burn without great difficulty owing to the carbonic acid gas mixed with it; and he had noticed that when the gases were best for burning, the temperature was so low in the top of the furnace that the materials were quite damp, and a long rod thrust in was drawn out covered with moisture. The gases ought never to be taken off hot through the tubes, if it could be avoided; and at Valenciennes in France, some of the best working furnaces he had seen were quite cool at the top, the gases being entirely taken off and the tops closed. He was so confident of the practicability of using the waste gases. that no provision had been made for a fire in the hot-blast stoves at his own works, intending to use gas entirely for heating them; but they had to put in a fire at first on starting the furnaces, though it was now used very little, and mainly at the time of starting. Some of the boilers were working without any coal fire, being heated entirely by gas; and the total quantity of coal used both for boilers and hot-blast stoves was less than 1½ cwt. per ton of iron made: the coal was a mixture of small coal and slack, costing only 4*s*. per ton. The use of gas saved the attendance of men for firing under the boilers and stoves.

Mr. C. **Cochrane** inquired what amount of irregularity had been experienced in the working of the close-topped furnaces. At the Ormesby Works he had found that for making the same quality of iron only 7 per cent. more coke was required during six months with the close-topped furnace than had previously been consumed in the same furnace before the gas apparatus was employed. But under the best circumstances irregularities would occur, arising sometimes from the level of the materials in the furnace being allowed to go down a few feet, from want of attention in charging, so that the materials did not get so thoroughly prepared before sinking to the point of reduction in the furnace; and there was more liability of this occurring in close-topped furnaces than in open ones, from the difficulty of seeing in to observe the level. He had found that his furnaces would sometimes turn round suddenly to white iron for a short time, and then return to grey iron; this was not of much consequence in the North of England, where white or mottled iron could easily be disposed of, but that was not the case in South Staffordshire.

Mr. T. **Snowdon** replied that change of weather and difference in the ironstone were the chief causes of fluctuation in the quality of iron and yield of the furnace; but he could not say that any material irregularity had resulted from taking off the gases. The iron produced from the close topped-furnaces appeared rather superior in quality, darker, and with larger crystals; and he had never found the furnace drop off from grey iron to mottled or white. In close-topped furnaces the materials at the top were not exposed to differences of dry or wet weather as in open-topped furnaces; his own furnaces had the top closed by a cylinder and charging cone, like that at Ebbw Vale, and were charged with a whole waggon-load of 36 cwt. at once, tipped direct into the furnace, so that there was no irregularity in filling, and a saving of labour compared with charging by barrows.

Mr. D. **Adamson** observed that if there were much variation in the temperature of the gases coming off from the furnace it would affect the draught produced by the chimney, and so might influence the working of the furnace: for when the furnace was so cool at the top as to be damp, the chimney would cause an increased draught and augment the current through the furnace; while a high temperature of the gases in the top of the furnace would partly counterbalance the heated column in the chimney, and the draught would be diminished. Care should be taken to have the fire-grates under the boilers and stoves closed air-tight, to prevent any air entering to impair the draught; and also to have a sufficiently high chimney to avoid any pressure of gas in the closed top of the furnace. If the chimney were large enough he could not see any reason why closing the top and taking off the gases should interfere with the proper working of the furnace; and thought there would even be an advantage in a close-topped furnace, by the pressure being relieved below that of the atmosphere, insuring a more active condition in the furnace under all circumstances.

◆

ON ARCHITECTURAL DRAWING.*

By W. Burges.

Before leaving the MSS. room of the British Museum I must notice one or two other drawings there deposited. The first is a design in perspective of a large and complicated tent: the plan may be described as like that of Canterbury and other cathedrals, viz., a cross with two transverses. The drawing is made in black lines, is tinted up with brown, and the ornaments touched up with yellow. The book known as Aug. iii., *Cotton*, presents us with several other tents, and a Renaissance fountain, the latter also in perspective, and tinted up with black or grey: it is likewise valuable to the artist as presenting him with several very large coloured figures of the costume of the time of Henry VIII.

The third drawing is a design for the tomb of Henry VI., which Henry VII., who revered him as a saint, had it appears intentions of erecting at Windsor; the execution however does not appear to have come off. The design is in bad perspective as usual, but drawn very carefully, probably with a ruling pen; the arches and angles also appear to have been done with a bow pen. The ink is a sort of dark sepia, it is also shaded very neatly and carefully with the same: there are no figures shown in the niches, and the line of impenetration is distinctly shown; whereas in some of the German drawings, if we may believe the engravings, the mouldings are simply drawn in similiar cases as ending in nothing.

The Society of Antiquaries have published also in the 'Vetusta Monumenta' the drawings representing the funeral of Abbot Islip. This very curious roll of vellum, which is now preserved in Heralds' College, is of great value both to the antiquary and to the architect, inasmuch as it presents us with sundry views of the interior of Westminster Abbey before the Reformation: the lines are thin, and the execution delicate. From it we learn what statues adorned the altar-screen, and what statues were placed above it. The dosel, exactly the most curious part, is represented as being covered up, but the brackets on the pediment of the wonderful tomb of Aymer de Valence are shown to have supported angels. Again, the blank wall-space in the chapel over Islip's Chantry, where now the wax-work is deposited, had a large picture of the Last Judgment, &c.; and another part of the roll presents us with the screens, now destroyed, which divided the chapels of the north transept from one another. Nothing can be much better than the drawing, both of the architecture and of the figures, in this roll. I may mention, as another proof of the value of documentary evidence relating to the same building, that the manuscript Life of St. Edward, written in the thirteenth century, shows us what figures were placed on the twisted columns at the western end of the Confessor's tomb. It appears that they supported statues, and, if we may believe the MS., coloured or enamelled statues of the king and St. John.

I must now take you to the print-room of the British Museum to examine the drawings of two of the greatest artists the world has ever produced, for we shall here find drawings made by the hands of both Albert Durer and Michael Angelo, both great in all the three arts, as I hope some day may be the case again with our professions. This day indeed will not come in our lives, but still we must do our best to help on the good time; and instead of fame, take the consciousness of having done our duty as the reward of our exertions. First of Albert Durer, for he closes one great period of art. In the print-room is a very large square folio volume, nearly filled with drawings by this master—at all events they are attributed to him, although I have always had my doubts how Albert Durer, although aided by great industry and a scolding wife, could have got through even one-half of the work attributed to him. His drawings are done in moderately thick lines, either with black or dark brown ink, and betray most certain traces of compass points, ruling pens, and bow pens. The first drawing I shall notice is the plan, looking down from above, of a most complicated fountain or pinnacle. There are pinnacles and pediments of an S-shaped plan, and indeed it resembles the almost impossible architecture that Israel Van Meekin designed on paper, and Adam Kraft executed in stone. There are a great many compass holes in this drawing, as if it had been pricked off. It is most carefully done, and the sections of the mouldings have the beads turned in with the bow pen; the lines of operation, such as the centre lines, are merely scratched on the paper, as it does not appear that they had means of erasing the lead lines: we shall see John Thorpe doing the same thing. Another drawing represents a tomb evidently Italian, beneath a vault supported upon four pillars; the drawing is done in black, and elaborately shaded with the same colour mixed with white; the lines are ruled. There are likewise designs for sundry pieces of jewellery; these are outlined in black or dark brown and then very slightly coloured with light washes of colour, the raised parts being left white. One design would appear to represent a large vase or fountain of the most elaborate description; from it the various figures pour out streams of liquid, which, as it is coloured red in one case, I, suspect to represent wine. There are two hands a little below the middle, which hold out cups, similar to those attached to the drinking fountains of the present day, to receive the noble juice. Indeed this design would make a most charming drinking fountain if executed in copper and enamelled, or indeed even in stone, painted; and I should be very much inclined to recommend it to the notice of the Drinking Fountain Association, whose designs certainly, to say the least, afford some margin for improvement. But to return to Albert Durer: three or four leaves of the book are occupied with a coloured design for a baluster column covered with arabesques; the drawing is most vigorous, and the colouring leaves nothing to be desired. The other drawings are more remarkable as curiosities than as having relation to architecture. Thus, there is the figure drawn from the model which he afterwards used in his beautiful plate of Fortune. The original figure is covered with squares, drawn with sharp points, evidently for reducing or enlarging it. At page 143 is a bird remarkably like the dodo; and further on a full-sized elevation and plan of a shoe of the period, a most valuable drawing for the writer on costume. Durer, in fact, appears to have had all the conveniences and appliances of modern times as regards his architectural drawing, but it is evident that his bow pen was none of the best, as his circles are the least neat parts of the drawings.

Now for Michael Angelo. The British Museum is not very rich in the architectural drawings of this master, yet is will probably be better to go through them, as they are more accessible to the student than those in other collections would be. They are for the most part sketched in with common ink (which has now turned brown) with a common pen, and drawn right off by hand, the circles being put in anyhow. Some of them probably have been first of all scratched in with charcoal, but we have no traces of it; one of them however has evidently been inked in upon something resembling chalk, or very black soft pencil. The drawings, even the details, are exceedingly rough, and if ever worked from must have been drawn out on a board by a pupil, and afterwards corrected by the master. They consist of all sorts of subjects,—windows, capitals, entablatures,

---

* Concluded from page 376, vol. xxiii.

&c.—but none of any great interest. The Musée Wicar, at Lille, is the place one must go to who wishes to see what the architectural drawings of Michael Angelo are really like. It appears that Wicar got hold of a sketch-book of Michael Angelo's, very similar in fact, to that of Villars de Honnecourt, and it is this book, cut up, and glazed and framed, which constitutes one of the riches of the Lille museum. The book contains architectural studies of the contemporary edifices—of those of Bramante and Brunelleschi; studies from classic buildings; and his own compositions, including the façade of St. Laurence, and the plan of the vestibule of the Laurentian Library; and lastly, directions for casting artillery. It is curious to compare this latter with the Trébuchet of Villars, so excellently described and elucidated by Prof. Willis. I find the following notes in my copy of the Wicar collection:—These drawings are executed in brown ink, with the help of a common straight-edge; there are no cross-hatchings, and where the plans are tinted they are done so in a very careless manner. Very often no straight-edge is used, and the lines are drawn in by hand; lines are often drawn with a blunt point on the paper. The same institution also contains the vellum sketch or pattern book of Francia. As many of these compositions are very small, ¾-inch by 1 inch, and others have the appearance of having been done for Nielli, it is not improbable to suppose that they were intended to serve him in his profession of goldsmith. One page contains ten Madonnas, each less than the other, the largest 1 inch square, and least ¾-inch by ⅜-inch. There are also on the same page twenty-four portraits, eight of whom are Turks, besides several other subjects, such as childrens' games, &c.

This museum also contains a copy of the drawing attributed to Van Eyk, of which duplicates are to be found, if I remember rightly, both at Bruges, Cologne, and I almost think Antwerp. It represents a female seated in front of a tower, holding a palm branch and book, the tower is octagonal or hexagonal, and in process of being built; it is drawn on paper, and entirely by the pen, except in some of the dark parts, where a little colour is dragged on to assist the lines; there is no cross-hatching, and occasionally small dots are used to continue the lines. It is covered with squares, and I suspect it to be a copy.

We must now return to England. By the kindness of Mr. S. Smirke I have been enabled to examine the drawings by Thorpe, preserved in the Soane Museum. As several of these drawings are already known by the fac-similes published by Mr. Richardson in his series of Elizabethan architecture, it will not be necessary to enter into the subjects represented. Thorpe appears to have had all the advantages which we have in the present day, except that he could not rub out his pencil or leaden point; thus the centre lines are done with a blunt point. His plans are very seldom etched, although there are one or two that are so treated, among them a very curious plan of Henry VII.'s chapel, showing all the screens as perfect, as well as the site of Edward VI.'s tomb in front of that of Henry VII., which tomb was put up by one of his sisters and destroyed by the other. It is curious that I did not observe any cast shadows in the tinted elevations of Thorpe, or indeed of any of those which I have been noticing. There are cast shadows, but they are worked up to a sharp edge. It was reserved to the moderns to make our drawings at once ugly and scientific. With Thorpe we take leave of the middle ages.

I here propose to close this small notice, merely calling attention to the very valuable and clever volume of drawings belonging to our library, and which contains a large number of sketches washed in bistre and indian-ink, apparently designs for scenes. Although belonging to the most Rococo period, yet they display a power of invention and design that would do honour to any age, and we can only regret that such good men should have fallen on evil times. We also possess a little sketch of Sir C. Wren's, done, like those of Michael Angelo, with the free hand with common pen and ink. At the end of the last century and at the beginning of the present, the fashion was to make drawings in fine lines tinted with indian-ink. At the revival of Mediæval art a favourite way of sketching was to outline in pencil and tint up with indian-ink or sepia. Most of Mr. Blore's drawings are done in this manner, and are so surprisingly and minutely finished, that they give the idea of very clear photographs. But before this the custom of offices was to make the drawings simply in thin lines, and then to back-line them, a practice destructive of all breadth of effect, and absolutely perplexing to the eye. The elder Pugin's works are specimens of this style, which, I am happy to say, is nearly obsolete. The younger Pugin brought the first change to the system in his plates, where he, on the contrary, made things look too well by his marvellous etchings. Indeed, there is a fizziness and an action in all his plates which you look in vain for in the real thing. The present system of etching up a drawing is an offshoot from this style, and is, I am afraid, open to very nearly the same objection. We have to thank competition committees for its use, who, forbidding the employment of colour, have obtained a much more seductive style of perspective; for I think I would any day back a good etched drawing against a coloured one.

But after all, the success of a design in stone and mortar must depend upon the working drawings (for nobody sets out work or chisels stone from perspectives), and it is in those that I hope to see strong, thick, bold lines employed, so that we may get into the habit of leaving out those prettinesses which only cost money and spoil our designs. But after all, no amount of architectural drawing would make a man an artist or an architect—for they are one and the same thing—unless he makes a complete mastery of the human figure; and I would earnestly suggest whether this Institute could not aid the attainment of this end, by having evenings when a model should sit and a good artist be engaged to correct the drawings. When the profession generally begin to draw the figure, and make bold architectural drawings, and generally to think for themselves, instead of going to past ages and precedents, we may then hope to have an ARCHITECTURE.

Prof. DONALDSON, in the course of some observations on the lecture, said it was a curious circumstance mentioned by Mr. Burges that Harold sent abroad for workmen, but it was known that during the pre-Norman style in England, English workmen were engaged. With respect to the collection of drawings at Lille referred to by Mr. Burges, he (Prof. Donaldson) had in 1853 drawn the attention of the Institute to those drawings, and he thought they were the production, not of Michael Angelo, but of Vasari. Of course that was a subject open to discussion, but from all the examinations he had made he was led to the belief that the drawings in question were not by Michael Angelo. In Italy a great many drawings of architects were preserved in museums. It was the usual practice for masters of the art, after the thirteenth or fourteenth century, to make one class of drawings in perspective, and another in geometrical proportion, and those drawings were generally executed in lines of sepia, with shading, more or less. The collection of drawings of the Duke of Devonshire at Chiswick was a very valuable one.

Mr. DIGBY WYATT regretted that Mr. Burges had not referred to the drawings of Holbein. The practice of drawing in thin line may have originated with the Anglo Saxon illuminists, who had all lined in a very thin style. In his opinion Leonardo da Vinci had a most beautiful style of sketching, and he thought also that they might well have congratulated themselves a little on the remarkable powers of the pencil possessed by some English architects, such as Inigo Jones, who drew with extreme skill, and with a fine bold line; Reynolds was a careful but not so artistic a drawer; and the brothers Adam had great power as draughtsmen. After referring to other artists whose drawings were very excellent, the speaker said, if they of the present day went on with purity and dexterity in drawing, they would inaugurate an epoch of rare prosperity for the fine arts, and he thought that this country was rapidly approaching to that.

Mr. SEDDON thought the real source of the thin-line drawing which they deplored was the invention of india-rubber. The object of drawing certainly was to explain a man's thought, and not to hide it, which seemed to be the only object of etching, which made a pretty drawing but did not explain the design, which the style of Villars de Honnecourt certainly did.

Mr. STREET said, it appeared to him that everyone who was worthy of being called an artist drew his own way, and ought to get on in his own style, and express himself in the most convenient way. They should so make drawings that they should be readily understood by workmen. Some much-abused architects had certainly shown them the way to go, and how to avoid the faults they themselves had committed.

Mr. PENROSE fully saw the advantage of every architect drawing and expressing himself in his own way; but still it was very desirable that the best schools of drawing should be pointed out to the student. Mr. Burges pointed out Michael Angelo as one of the best authorities, if not the best, in a particular style. Now, he believed that the best collection of that artist's sketches was at Oxford, and in looking over them six or seven years ago, he did so with the greatest pleasure and satisfaction. The drawings at Bologna were of an exceedingly interesting character. Those of Palladio were drawings in a thoroughly straightforward, practical style, with moderately thick lines. Palladio unfortunately was no sculptor; he could not draw the figure. Had he been able to do so, he would have been all that his most enthusiastic admirers claimed for him. He thought their fears were over-excited in reference to pencil lines, and the necessity for giving up the india-rubber was becoming unnecessary, because for the last dozen years he had not seen a pencil mark that would rub out. It occurred to him that any person accustomed to draw out-of-doors, from real buildings, would necessarily follow the natural style, because he would endeavour to represent the building before him.

Mr. Kerr thought there was a distinguishing style of drawing, just as there were distinguishing styles of architecture. There was, he was of opinion, in the present day, the Classic style of drawing and the Gothic style of drawing. In *quasi* Classical forms in the last century the style of drawing of this country was decidedly of a Classical character—the lines were fine and the shadows indicated in a certain manner,—whereas now that the style of design had changed into the romantic and picturesque style of architecture, the tendency was to the romantic and picturesque style of drawing. The style of drawing was part and parcel of the mind of the man, and which he followed by the evident necessity of his mind.

Mr. White protested against the notion that either picturesqueness was solely applicable to the Gothic school, or that picturesqueness was the sole or the great element of the Gothic school. Again, he protested against the notion that grace, beauty, and refinement, were to be found solely in Classic architecture, or that they were solely the elements of that school. He believed that they were common to both; that it was much more a question of southern and northern architecture than Gothic or Classic; and that the thickness of line depended much more on the amount of finish intended to be given to the drawing than to the representation of any style of an architect. He had found the thickness of line depend very much on the sharpness or bluntness of the pencil.

Mr. Ferrey thought the proper plan was to draw the forms in a pure, clear manner. He would not discuss the question whether the drawing should have a line the sixty-fourth part of an inch or the eighth part of an inch, but it should be the clear expression of the form intended to be executed. He thought that Mr. Street was right in saying that every architect should throw into his drawings the expression he wished to make as an artist.

Mr. G. Godwin said he thought the paper an excellent one. The lecturer said that to deceive a client was allowable in an architect, and at one time it was so; but he believed that a higher feeling prevailed now, and that an architect would think it a disgrace to himself if he deceived his client. He could not agree with the condemnation of all crockets and fizzings, for that would lead to a very bald style of architecture.

ON THE TREATMENT OF STEAM FOR THE DEVELOPMENT OF POWER.*

By J. G. Lawrie.

Engineers have within a recent period made considerable progress in acquiring a knowledge of the principles of steam. They have become acquainted with Joule's Law, which enables them to comprehend elements of the action of steam formerly obscure. They now know that the power which can be obtained from steam is measured by the heat it contains, and that the heat necessary to raise the temperature of a pound of steam one degree is as exactly defined by, and as exactly equal to, a known amount of power, as 1 ton is equal to 20 cwt. By means of this knowledge the investigation of the amount of power derived from a quantity of steam used by any steam-engine, is reduced to an investigation of the amount of heat contained in the steam when it enters the engine, of the amount of heat contained in the steam when it leaves the engine, and of the conversion of the difference.

Proceeding in this way the action of expansive steam-engines has been elaborately considered by scientific men; but in all the investigations with which I am acquainted, the engines considered have been what mathematicians would call pure or immaterial engines. No account has been taken in these investigations of the effect in the action of the engine due to the substance of which the engine, and more particularly of which the steam-cylinder, is composed. The results arrived at are therefore those that would be true if the parts of the engine were absolutely impervious to heat; and they afford important and conclusive information regarding the operation of steam on that supposition.

But, in the practice of engineers, the effect derived from steam-engines is the result due to a complicated action arising from the radiation of heat, the conduction of heat, the transference of heat, by means of the substance of the steam-cylinder, &c., from one part of the stroke to another, and also very materially the result obtained is affected by the action of the valves. In this complication care is necessary to discriminate between the different causes, so as to arrive at proper conclusions regarding the effects.

In illustration of this, the opinion entertained by some engineers that the use of expansion in unjacketed cylinders is productive of no advantage, and by other engineers of loss, is, the writer believes, unwarranted by the present state of our knowledge on the subject; and he also believes that the opinion of the use of the jacket being productive of some recondite and unintelligible advantage, is equally without solid foundation. To obtain the same amount of power from an expansive engine that is obtained from one in which expansion is not used, the cylinder requires to be made of increased size, which occasions loss no doubt from increased radiation and increased conduction, whether the cylinder be jacketed or not, but not to an extent of any moment in the consideration of this question.

In estimating the power derived from a quantity of steam, it is necessary, as has already been mentioned, to consider the quantity of heat which the steam carries into the cylinder, and also the quantity which it carries from the cylinder. In the proportion that the latter of these quantities is less than the former, the duty or performance of the steam is increased. In an engine working without expansion, that is with full steam throughout the stroke, a certain smaller quantity of heat leaves the cylinder than entered it, the difference having been transformed into power; and in an expansive engine in which the steam is admitted during only a part of the stroke, the duty or performance of the steam cannot be less than in the former engine, unless the steam carries from the cylinder more heat in the expansive engine than in the engine in which the steam is not expanded. Some engineers entertain an opinion very unfavourable to the use of expansion in an unjacketed cylinder; and of these Mr. Humphrys, of London, states broadly his opinion that the use of expansion in an unjacketed cylinder is always productive of loss, and that the amount of loss is proportioned to the amount of expansion used, the loss beginning with the smallest amount of expansion, and increasing as the expansion is increased, to an extent so great that, when the expansion is considerable, three times the quantity of coal and steam is necessary to produce the same effect that is required when expansion is not used.

The writer has mentioned that, in an engine in which steam is admitted of full pressure throughout the stroke, the quantity of heat which leaves the cylinder at the termination of the stroke is less than the quantity which entered the cylinder at the commencement; and, if the opinion of Mr. Humphrys be correct, it follows as a consequence that in the expansive engines upon which he rests his opinion the difference between the amount of heat which entered and left the cylinder when the engine worked expansively, must have been only one-third of the difference between the heat which entered and left the cylinder when the engine worked without expansion. Thus, in an engine in which the steam is admitted throughout the stroke, if the quantity of heat which enters the cylinder be represented by unity, or $\frac{45}{45}$, the quantity which leaves the cylinder and is lost, is $\frac{42}{45}$,* leaving the difference $\frac{3}{45}$ as the quantity utilised. Therefore in the engine upon which Mr. Humphrys experimented, the quantity of heat, if his views be correct, which leaves the cylinder and is lost is $\frac{44}{45}$, leaving the difference $\frac{1}{45}$ as the quantity utilised when the expansion is considerable. The duty of the coal, or heat, or steam, in the two engines is very different, being in the one engine $\frac{3}{45}$, and in the other $\frac{1}{45}$; yet the difference in the two engines in the heat which is lost proportionally to the whole heat is very inconsiderable, being in the one $\frac{42}{45}$, and in the other $\frac{44}{45}$. These figures bring out prominently the necessity for high perfection in the construction of engines, and the facility with which a slip may be made from a result that is good to one that is bad. There are several ways in which the good result, namely, the one in which the loss of heat is only $\frac{42}{45}$, may be diverged from; but on comparison of the two engines, the expansive and non-expansive, it is exceedingly difficult to see how the effect stated by Mr. Humphrys can take place in a manner due only to expansion or non-expansion.

---

* Read at the Institution of Engineers in Scotland.

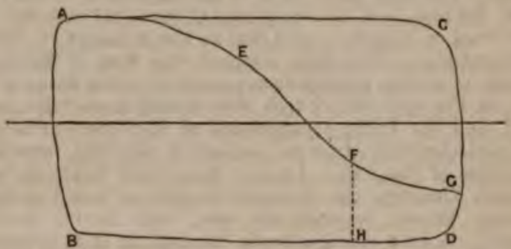
* See note at end of paper.

It has been alleged that in an unjacketed cylinder the heating and cooling of the cylinder at the beginning and termination of the stroke accounts for a loss of advantage in the use of expansion, but it does not at all account for it as identically the same operation: the same addition of heat to the steam during the progress of the stroke takes place in a jacketed cylinder. Except in the loss arising from the radiation and conduction due to the increased surfaces, the writer knows of no explanation which satisfactorily accounts for the results found in the experiments of Mr. Humphrys, and the loss arising from these causes cannot, under usual circumstances, be of an amount to afford the explanation.

In other experiments on this subject,—in those for example on which a distinguished member of this Institution rests his unfavourable opinion of the use of expansion in an unjacketed cylinder,—not a loss, as with Mr. Humphrys, but a result giving no advantage, as the writer understands, was obtained. The result obtained however in the instances to which the writer now refers, is capable of an easier and more satisfactory explanation. When expansion is used it is necessary that the steam be freely admitted to the cylinder during admission, that it be sharply cut off, and that it be retained in the cylinder hermetically till the period for its emission. These conditions, the writer believes, were not fulfilled in the experiments to which he alludes. In the steamer Islesman, for example, an account of which has already appeared in the Transactions of this Institution, the mode of effecting the expansion is, in the writer's opinion, of a defective character. In the account of that vessel it is stated that in a stroke of 36 inches, when the steam is admitted during 4 inches, the exhaust is opened at 26 inches, and the compression begins at 20 inches. In the gear by which the valves of this machinery are actuated, the amount of expansion is increased by reducing the travel of the valves, which has the effect of checking the free admission of the steam, of unduly increasing the compression, and of opening the exhaust at a period of the stroke when it should be closed. All of these effects are disadvantageous to the development of the power of the steam.

In the same way with those engines in which the expansion valve is placed in the steam-pipe, or on a stationary plate of the valve casing, the expansion is effected in an unsatisfactory manner, and there is no doubt that in all of these cases the result, whatever it may be, is less advantageous than it would be with an efficient mode of effecting the expansion.

It may be said however that the diagrams obtained are satisfactory when these modes of shutting off the steam are employed, and no doubt they often are, as in the diagrams of the Islesman, which were exhibited in this room. Now however that the pressure and power of engines is measured with so much minuteness, the indicator is far from being an instrument sufficiently delicate for the purpose, and the diagrams of the Islesman appear to establish this fact. Even with the greatest care the indicator in a tapering diagram is not to be depended on for accuracy, and, with the slightest inattention, the indications are very far from the truth. In the diagram, represented by A, C, B, D, the indicator probably represents, with tolerable accuracy, the pressure in the cylinder, because the changes of pressure from B to A, and from C to B, are large in amount and sudden; but in the tapering diagram represented by the line A, E, F, G, D, the changes of pressure being gradual, and in fact imperceptible, the pencil will necessarily fall behind the changes of pressure in the cylinder by an amount depending on the circumstances of the case, but by an amount which, in all cases, is of considerable importance, and in many of large amount. In the Islesman, for example, the steam is released at 10 inches from the termination of the stroke; yet the diagrams did not assume the shape represented by the line E, F, H, D, which they ought to have done; nor is the shape of that character in any diagrams the writer has seen, although in all it ought to be more or less, as in all engines the steam is released before the termination of the stroke; and this proves either—or rather proves both—that the diagram is incorrect, and that the steam requires a considerable time to escape even into a vacuum. But if a time so considerable is necessary for the steam to escape even into a vacuum, the multifarious plans of effecting expansion by means of valves in the steam-pipe, and valves placed over numerous small apertures through plates in the valve-casing, must be radically injurious, as they entail small tortuous passages, through which the steam cannot possibly travel with the freedom desirable.



The writer has already explained that, in his opinion, the reason why in certain cases no advantage has been derived from the use of expansion in unjacketed cylinders, does not exist in the heating and cooling of the steam cylinder, and that jacketed cylinders do not possess in that respect any material advantage; yet in other respects jacketed cylinders possess advantages which are exceedingly important. In steam which has not been subjected to any superheating process, a considerable quantity of water is carried in mechanical suspension, and when the steam is used to work a steam-engine with an unjacketed cylinder, a further quantity of water is produced by the condensation of the steam in the development of power. But, in an expansive engine with a jacketed cylinder, the temperature of the steam in the cylinder being lowered during expansion below that of the steam in the jacket, the latter becomes a means of superheating the steam within the cylinder, and so converts the water in mechanical suspension, as well as that due to the development of power, into steam, and effects in that way an important economy of fuel, provided the heat contained in the condensed water of the jacket be returned to the boiler. This appears to the writer to be the chief advantage of the steam jacket; and for the reason that he does not see a loss due to the heating and cooling of an unjacketed cylinder, neither does he see any very considerable advantage in a jacketed cylinder when the steam is superheated to an extent to prevent condensation during the development of power. Until, however, this superheating can be effected in a safe and mechanically simple way, the economy attainable with a jacket is unattainable without it.

Note on expansive engines.—The figures referred to by the writer are obtained as follows:—1 lb. of coal evaporates $7\frac{1}{2}$ lb. of water, and therefore the water receives $1150 \times 7\frac{1}{2}$ of heat $=$ 8625°. One horse-power per hour $= 33{,}000$ lb. $\times\ 60$; 1 foot high $= 1{,}980{,}000$ lb. $= 2538°$ of a pound of water at the rate of 780 foot-pounds for 1 degree. Therefore, the horse-power due to 1 lb. of coal $= \frac{8625}{2538} = 3{\cdot}4$-horse power. But, $4\frac{1}{2}$ lb. of coal are required per horse-power in a good non-expansive engine, and therefore only $\frac{1}{3{\cdot}4 \times 4{\cdot}5} = \frac{1}{15{\cdot}3}$; or, in even numbers, $\frac{1}{15} = \frac{3}{45}$ of the heat received by the water is utilised, the remainder $\frac{42}{45}$ being lost. In the s.s. Thetis, at $1\frac{1}{2}$ lb. per horse-power, the heat utilised is $\frac{9}{45}$, and the remainder $\frac{36}{45}$ is lost. In the engines by Randolph, Elder, and Co., at 2 lb. per horse-power, the heat utilised is $\frac{6{\cdot}75}{45}$, and the remainder, $\frac{38{\cdot}25}{45}$, is lost.

CHURCH AND CONVENTUAL ARRANGEMENTS.*

By the Rev. Mackenzie E. C. Walcott, M.A.

The "Upper Chamber" of Jerusalem was an ordinary dwelling-room, built, like many of the Norman houses, over store-chambers. The first mention of a church occurs in St. Paul's Epistles, the next is of the early part of the third century. The word κυριακον, or church, occurs first in the writings of the succeeding century.[1] The form adopted was that of an oblong, allegorical of a ship, a symbolism preserved in the name of nave (navis), as the spiritual church was described as "the Ark of Christ;" and the triple arrangement of the lower arcade, triforium, and clerestory, bear an analogy to the first, second, and third stories of the Ark. In the 'Apostolical Constitutions of the Fourth Century,' the direction is given—"Let the church be oblong, turned towards the east, with lateral chambers (παστοφορια) on both sides, towards the east, as it is to resemble a ship: let the bishop's throne be in the midst, with the presbytery sitting on either side, and the deacons standing by."[2] The Church of SS. Vicenzo and Anastasio, at Rome, built by Honorius I., c. 630, has its walls curved like the ribs of a ship. However, in the poem of St. Gregory Nazianzen, 'The Dream of Anastasia' (Carm. ix. Op., tom. ii. p. 79), mention is made of "a Christian temple of four parts, with aisles in the form of a cross." At Djemilah, in Egypt, Lenoir states that the foundations of a church anterior to the time of Constantine were discovered: it contained a square cella, inclosed by walls; a nave, of five bays, with arcades opening on three colonnades, without a porch, but having a door on one side.

At Thebes,[3] Baalbec, Philæ, Sebona, and Maharraka, mentioned by Belzoni, the Christians effected a new internal arrangement of the pagan temples, a plan not uncommon, as we find in Eusebius, c. 380,[4] and in Sozomen.[5] The atrium was roofed in and subdivided, as a nave, into aisles. Eusebius,[6] describing a church or basilica at Tyre, built c. 313—322, by Paulinus, mentions in it a semicircular apse, having sacred inclosures, and forming a holy of holies. Stalls for the bishop and clergy ranged behind and around a central altar, with a wooden trellised screen parting it off from the nave, which was a square divided into three alleys; seats for the congregation; a lectern in the centre of the nave, flanked by singers and communicants; side porches, and a large vestibule; upper galleries for women; and lastly, a square court surrounded with a trellised colonnade, and having a fountain in the centre. It is not difficult to recognise here the antitype of the Jewish temple, which contained a triple division—the inner sanctuary, preceded by an enormous porch, and subdivided into (1) the worldly sanctuary, (2) the holy of holies, and (3) the outer court of worshippers. From the fourth century a corresponding and uniform division of the Christian churches was made, and the two former appellations frequently were re-applied. A church at Edessa[7] was thus modelled, c. 202.

In the Church of the Apostles built at Byzantium by Constantine, the rooms of the priests were built along the sides of the colonnade, as in the Temple of Zion, as the baptisteries were also circular, in imitation of Solomon's sea of brass. A relic of this international correspondence may be traced in the entrance on the east in the old churches of Rome, St. John Lateran, St. Cecilia, Quatuor Coronati, St. Peter, St. Clemente, and originally in those of St. Paul and St. Lorenzo, an arrangement that re-appears in the decline of Gothic art at Seville, although another assignable cause is the original ground-plan of the basilica having an entrance on the east. The Parthenon and Temple of Theseus were exceptions to the rule of orientation observed by the Greeks, and according to Hyginus and Plutarch, by the Romans. Paulinus of Nola (ep. xxxii., ad Severum) mentions that the church there was a similar exception. Sidonius Apollinaris, speaking of the church of Lyons built by Bishop Patient, faced the east; so also did St. Mary's, Antioch,[8] and that of Tyre, both built by Constantine. Walafrid Strabo says that the principle of orientation was introduced only after a considerable lapse of time. Tertullian (Adv. Valent., c. 2), c. 200, speaks of the church facing the east.

The Byzantine arrangement was of three kinds. 1. The circular, as at Jerusalem, imitated in the round churches of the West. The basilican, with apsidal termination to the transepts, as at Bethlehem, imitated at Noyou, Soissons, and Bonn. 3. The so-called Greek cross, as at St. Sophia, Constantinople, imitated at Provence, owing to commercial relations with Greece and Constantinople; in the west of Aquitaine through the intermediate step of St. Mark's, Venice, owing to Venetian settlers; and on the borders of the Rhine, owing to the support given by Charlemagne to Oriental art.

The circular form of the Holy Sepulchre built by the Empress Helena at Jerusalem, rebuilt by Charlemagne in 813, was caused by its erection round a tomb: octagonal churches, such as those of Antioch and Nazianzum, like baptisteries, were built on symbolical designs. The church erected on the Mount of Ascension powerfully affected the Eastern mind, and became a model for similar buildings, the domes of which were inscribed with the grand words of the angelic salutation to the apostles.[9] The dome was a necessary constructional development as the fittest covering for a round building. Constantine built the first round churches in the West, those of St. Constance, and SS. Peter and Marcellinus, at Rome. In the interior of the latter, and of St. George, Salonica, built by him, with its seven trigonal chapels; in those of the Holy Sepulchre; and in the eight little apses of the Church of the Apostles, at Athens; and of St. Vitalis, at Ravenna, built by Justinian, we observe a singular resemblance to the chevet with its radiating chapels. An octagonal church, internally circular, occurs at Hierapolis, of an early date. Circular and polygonal churches are also frequent in Armenia. That of Etchmiasdin is a square, with a central dome and apses to each arm of the internally marked cross.

In the Church of the Apostles at Constantinople, Constantine adopted the form of the Latin cross, as in the Church of St. John Studius, and a central dome above the sanctuary;[10] the nave had timber roof. However, the necessary construction of four pillars to carry the dome, and of vaults to the nave and transepts, led to the abandonment of the flat ceilings and roofs of the Latins.

The circle or polygon was thus combined with the Latin cross; and the gammada, or Greek cross, arose from the combination of four gammas, the numeral designating the Holy Trinity. Arculphus describes a church of this form at Sichem, in the seventh century. The cupola in time was extravagantly developed, and the aisles reduced to narrow passages in the time of Justinian. St. Sophia, consecrated A.D. 557—of which the Emperor Justinian said, with a burst of emotion, "I have equalled thee, O Solomon!"—forms a square with an eastern apse and a central cupola, and the form of the cross is formed internally by two square halls on either side of the dome; a portico ranges along the entire front of the building, as at St. Vitalis, Ravenna. Sometimes doors only mark the form of the cross. Cupolas erected over each of the four arms served the same destination. After the reign of Justinian, the Eastern churches received a better arrangement, a central dome, a nave with aisles (there are five in the Panagia Nicodemi at Athens), an inner porch, and three apses to the choir, as at Mistra. In the Benedictine Church of Daphnis, near Eleusis, probably built by the Venetians, the ground-plan is a Greek cross, with central and eastern cupolas, an apsidal choir, aisles, and square lateral chambers. The dome, at first flattened, as the builders grew bolder was afterwards elevated, after it had received the addition of a supporting arcade, pierced with windows. The latter were round-headed and sometimes arranged in triplets, and were closed with trellises of stonework. Belfries were of late introduction in the East, by the Maronites in the thirteenth century,[11] as the wooden clappers were long retained, and did not appear until the Franks began to exercise ostensible influence. There is one of the Pointed period at Mistra, and a central tower occurs in Tenos. Chapels seldom occur until the fifteenth or sixteenth centuries. After the Turkish invasion domes fell into desuetude, and the Latin cross was adopted. The central apse formed the sanctuary, with the altar in the chord;

---

* Read at the Royal Institute of British Architects.

[1] Lamprid. Vit. Sev. c. 49; Chron. of Edessa., ap.; Asseman. Bib. Orient., tom. i. p. 57; Tert. de Idol., c. 7; Adv. Val. c. 3; De Cor. Mil., 8; De Pud., c. 4; Cyprian Ep., lv. 33; Greg. Thaum. Ep. Can., c. 11; Greg. Nyss. in Vit. Greg. Thaum.; Dionys. al. Ep. Can., c. 2; Lactant. Inst. Div. l. v., c. 11; De Mòrte Persec., c. 12, 45; Ambros. in. Eph., iv.; Euseb. H. E., l. viii., c. 1, 13; Optat. de Sch. Don., lib. ii., c. 4.

[2] Ap. Const., l. ii., c. 57.

[3] Lord Lindsay, i. p. 11.

[4] Hist. Eccles., iv. 24.

[5] Hist. Eccles., vii. 15.

[6] Hist. Eccles., x. 4, 21, 43. See also St. Paul, Op. ed. Muratori, c. 203, in col. 912; and Faber's Vigilantius, p. 177.

[7] Note of Michaelis; Rose's 'Neander,' i. 246.

[8] Socr. Hist. Eccl., lib. v. c. 22.

[9] Acts, i. ii.

[10] Eusebius; St. Greg. Naz. Somn. Anast., c. ix.; Procop. de Ædif. Just.

[11] Fleury, lxiii. 46.

the northern the prothesis, or place of the credence; the southern was the sacristy or diaconicum; the choir was arranged under the dome, and separated from the altar by the iconostasis, a solid screen[12] with a central door, hung with curtains;[13] the men sat below, the women occupied galleries. The chancel screen, κικλιδες, is first mentioned by Theodoret.[14] Sometimes[15] the men were on the south and the women on the north side. The choir sat on either side of the αμβων, or pulpit, which had a little desk attached to it for the use of the reader. A long, narrow, wand-like colonnade (the narthex) before the west front, imitated in the porches of St. Mark's, Venice, of a later period, had three doors,—the central for the clergy, the north for women, and the south for men. It was at once a baptistery, chapter-house, vestry-room, and lych-gate; and was occupied by the catechumens and penitents. It contained a stoup[16] for washing. It was sometimes provided with an inner narthex. St. Chrysostom and St. Augustine used to preach from the altar steps.

The cross was not set up in churches until the middle of the fourth century, and towards its close pictures of saints and martyrs were introduced. The earliest sculpture is that of the Good Shepherd, carved upon a chalice, as mentioned by Tertullian.

I may mention in passing that the first notice of a formal consecration of a church occurs in the fourth century; that Venantius Fortunatus makes the earliest mention of the use of glazing, when speaking of the Cathedral of Paris; and the custom of burials within the church may be referred to the interval between the seventh and tenth centuries, and was of gradual introduction.[17] St. Gregory, of Tours, says it was a Frank custom to hang tapestry round the altars of martyrs.

The Byzantine style, which has been called a combination of the Latin basilica and the round chapel of martyrdom (the latter being derived from that of the catacomb or more probably the round church of Jerusalem), exercised a widely-extended influence, seen not only in the flat cupolas of the Saracen, the apse of the Armenians, and the bulbous dome of Russia. The Catholicon Cathedral at Athens, probably the oldest Greek church remaining, and perhaps anterior to the time of Justinian, is nearly identical in ground-plan with that of St. Basil, Kieff, of the close of the tenth century. The Cathedral of St. Sophia in that town, of the eleventh century, consists of seven apsidal aisles, with broad lateral and also apsidal additions. The Russian type was a square ground-plan, a central dome surrounded by four cupolas, three apses, and a narthex, according to Mr. Fergusson, and found in the fifteenth century in the Church of the Assumption, Moscow, built by a Bolognese: but the lateral eastern apses are parted off by screens into chapels. It is also perceptible in the West in the Byzantine cupolas, introduced primarily owing to the influence of Venetian commerce and colonists; at St. Front de Perigueux, built 984-1047, on the plan of St. Mark's, and presenting a narthex; in the cupolas of Cahors and Angoulême at the beginning of the twelfth century; at Souillac, Salignac, St. Hilaire de Poicters, and Fontevrault; in the chapter-house of St. Sauveur, Nevers; in the three eastern apses and the porch of Autun, c. 1150; at St. Medard de Soissons, built 1158, in imitation of St. Sophia—all buildings of the eleventh and twelfth centuries; and up to the twelfth century in the churches of Normandy, Aquitaine, Poitou, and Anjou, while the Basilican and Byzantine forms are united. It is seen in the round churches of St. Constance, built by Constantine at Rome; St. Stephen's, of the fifth century, on the Cœlian Mount; St. Martin's, at Tours; St. Benignus, at Dijon, of the seventh or eighth century; at Aix, built by Charlemagne, a church imitated, in the twelfth century, at Ottmarsheim; at St. Germain Auxerrois; at Perugia, Bergamo, and Bologna, in the tenth and eleventh centuries; at Charroux in the twelfth century; at Segovia, Montmorillon, Leon, Metz; in England in the Temple churches (that in London was consecrated by Heraclius, Patriarch of Jerusalem); in the foliated octagon of Justinian in St. Vitalis, Ravenna, bearing a marked affinity to St. Sophia, and the earliest Byzantine church in Italy; in the apsidal terminations to the transepts of St. Martin's, Cologne, c. 1035, St. Maria del Capitulo, in the same city, of the twelfth or thirteenth century; at St. Germigny de Pres, built 807, as at Bethlehem, and at Noyon, of the twelfth century; in the ground-plan of St. Tibertius at Rome, of the time of Constantime; of St. Cyriac, Ancona, of the close of the tenth century; St. Cæsar at Arles; SS. Vincent and Anastasius, Paris; at Torcello; and lastly, in the superb Cathedral of St. Mark, completed in the eleventh and twelfth centuries, which contains the pulpit and iconostasis of St. Sophia as well as a rood-screen.[18]

In the East, the clergy-house (παστοφορια, Sept. Trans. Ezek. xl. 17), libraries, a guest-house, and decanica or prisons, adjoined the church.[19] These outer buildings were known as exedrai; and the garth, which succeeded to the pagan temenos, as the peribolos, tetrastöon and peristöon.[20] The pagan temples in the West were, from their small size and peculiar arrangements, not readily convertible into churches; the earliest so transformed was probably the Pantheon, consecrated as All Saints' in 610; the next perhaps, St. Urbano Alla Caffarelli, in the suburbs of Rome. The Parthenon of Athens was transformed into St. Mary's.

When the Christians obtained the right of toleration and open celebration of public worship, they took as their model or rather actually occupied the basilica, tribunal, exchange, and hall, which by their form and dimensions were admirably adapted for the purpose; they retained the name of basilica, understanding it in the sense of the "palace of the Great King." The name may be traced back to the Stoa Basileios of the Archon Basileus; the Porcia, the first built at Rome, was erected 210 B.C., by Porcius Cato. The judgment-hall of Pilate was a basilica, and its gabatha or pavement the raised tribune. St. Paul, apparently, was a prisoner in the crypt of Herod's basilica. The atrium remains perfect in St. Clementi, which, though rebuilt in the ninth century, is a complete specimen of a basilica of the fourth or fifth century; also at St. Laurence Without, St. Agnes, St. Praxedes, and St. Cecilia. In St. Ambrogio, Milan, rebuilt in the twelfth century, is an apsidal basilica fronted with a large atrium. The apse, with one of the western towers, dates from the tenth century. At Segovia, St. Mellan has lateral exterior galleries, a feature common to this part of Spain and Germany, being the peristyle turned inward in a transitional state to the cloister. Constantine converted the Vatican and Lateran basilicas into churches, and these formed a type for subsequent structures. The plan was the following:—In front of the church was a court, atrium, or paradisus, like the court of Gentiles in the Temple; and the prototype of the future cloister, surrounded by a colonnade; entered by a vestibule (prothyrum), and having a fountain (cantharus) in the centre, covered by a cupola, at which the faithful washed their hands before entering the church. This court served as a cemetery, and station of penitents, catechumens, and neophytes. Where the court was wanting they assembled in the narthex, a porch in front of the church into which the doors opened; on the left side of it was the font.

The basilica itself was a parallelogram, forming with its pronaos and alæ a nave, divided into three, or sometimes five alleys. The central body had sometimes an upper gallery or triforium for women auditors. The aisles on the right-hand were allotted to men, those on the left side to women, the tribunes and galleries on the left being given up to widows, and on the right to young women who had undertaken a religious life. In Trajan's five-aisled basilica, 360 feet by 180 feet, and 125 feet high, there was a gallery of this description. In the centre of the platform of the apse the prætor or quæstor had sat, and on either side, upon a hemicycle of steps (which on the ground-plan is subdivided like the radiating chapels of a Gothic minster), had been ranged his assessors. In the chord of the apse had been the altar of libations. In the three-aisled basilica of Maxentius, built three centuries later, we find a lateral apse resembling that of Germigny de Pres. The chalcidicæ, the transverse aisle, occupied by the advocates, became the transept, as at St. Paul's, c. 386; and St. Maria Maggiore, c. 432; and the five-aisled basilica of St. Peter, c. 330, where in the latter case it extends beyond the line of nave, to connect it with two circular tombs on the north side, which possibly covered the apostle's place of martyrdom, and may have suggested the round tomb-houses of a later period. At St. Apollinaris, Ravenna, c. 493—525, the transept is wholly wanting, but a rectilinear compartment inserted in front of the great apse offers the first approach to a modern chancel. At

---

[12] St. Chrys., Hom. 3, in Ep. ad Ephes.; Evagr., Hist. Eccles., vi. 21; Paul. Nol. Nat. Felic. iii. 6.

[13] Greg Naz. Carm. ix.; Evag. Ecc. Hist., iv. 31.

[14] Hist. Eccles., v. 18.

[15] Const. Apost., ii. 57; Cyril Hier. Pro Catech. 8; St. Aug. de Civ. Dei., ii. 28; St. Chrys., lxxiv.; Hom. in St. Matt.; Bona de Reb. Liturg , quoting Philo.; St. Ambros. de Virg., &c. Origen in St. Matt., tract xxvi.

[16] Conc. Laod., c. 15.

[17] Tert. de Orat., c. xi., Euseb. Hist. Eccles., x. 4; Chrys. Hom. in lii. in St. Matt.; Ps. cxl.; Synes, Ep. 121.

[18] Cap. Theod., A.D. 994, c. 9; Canons, A.D. 960, c. 29.

[19] Viollet le Duc, i. 135, 171-2, 210, 216: Le Noir, Arch. Mon.

[20] Euseb.; St. Aug.; St. Jerome; St. Basil.

Pisa, towards the close of the eleventh century, we find the transept thus developed, with an apse extended into a choir. The triforium gallery under the aisle roofs is found at St. Lorenzo, c. 580, and St. Agnese, c. 625; and Quatuor Coronati, c. 625. But the system never came into general use, owing to the preference for a long entablature covered with pictures or mosaics. At Conques and Fontifroide galleries were constructed in the nave aisles. In the early German churches, near Bonn, a manner-chor—a gallery for young men—is found in the triforium (Whewell, Germ. Arch. p. 91). At Parenzo c. 542, and at Autun, c. 1150, there are three, and at Torcello, five, of the beginning of the eleventh century, eastern apses; at St. Miniato, begun 1013, there is but one. At Romain Mortier, c. 753, the plan included a stunted transept, three apses, a narthex of the tenth century, and a west porch like a small galilee of the eleventh or the twelfth century. Ara Cœli, at Rome, had a cruciform shape.

The dais of the apse was railed off by cancelli for a presbytery or bema, where the bishop occupied the quæstor's chair (cathedra); remaining at Parenzo, St. Clemente (of the ninth century), St. Agnes, SS. Nereus and Achilles, Rome; and the priests the seats of his assessors (exedrai).[21] A choir was added constructionally, which reached into the nave, from which it was separated by a marble balustrade (septum) for the choristers, acolytes, &c. Ambones or pulpits were erected on either side of the chancel arch or door: one (analagion) for reading the epistle; the other (ambo) for reciting the gospel, serving also as a pulpit, with the paschal candlestick placed on a stand beside it, reproduced in French cathedrals, at Paris and St. Denis, at the top of the sanctuary stair. A triumphal arch (porto sancta, or regia) formed the entrance to the sanctuary, which contained the altar, covered by a "ciborium"—a "cibo sacro," from the reservation of the host, or from the shape of its cupola resembling the Egyptian bean—a pavilion raised on columns, and standing above the crypt or confession. The theory was that every church (as St. Agnes, St. Lorenzo, St. Martino, and St. Praxedes) was erected over an actual catacomb; where this was impracticable a crypt was made, and the ciborium or tabernacle was an imitation of the sepulchral recess of the catacomb. There were two tables of proposition, one for the elements and one for the vessels used in the office: one remains at San Clemente; two at SS. Nereus and Achilles, Rome, c. 800. Where there were secondary or eastern aisle-apses (pastoforia), that on the left (diaconicum minus) served as the sacristy, library, and muniment room; that on the right (prothesis) as the vestry and credence-chamber.

St. Peter's at Rome had two aisles on each side of the nave, a transept on a level with the nave, and an apse on the west side; with a floor raised to a height of 5 feet, forming the platform of the presbytery, which extended about 9 feet into the transept. The entrance was at the east end. At the extreme west point was the pontifical chair, raised on a platform above the level of the presbytery; on the right and left of the chair the walls of the apse were lined with the seats of the cardinals. At the edge of the platform stood the high altar, under a ciborium or canopy; it was raised by steps above the level of the presbytery. On each side a flight of five steps led down into the transept. Beneath this platform was a semicircular crypt, close to the walls of the apse, used as a burial-place of the popes. The entrances were at the junction of the choir and transept. In front of the high altar was the entrance to the confession, the subterranean chapel of St. Peter, containing an altar. In front of the steps were twelve columns of marble, in two rows, said to have been brought from Greece, or Solomon's Temple; and being inclosed with marble walls breast high, and lattices of metal-work, formed the vestibule of the confessionary. At the beginning of the thirteenth century the stairs to the confessionary were removed and the entrance blocked up. The nave was divided from the transept by the triumphal arch, under which a beam was fixed, and in the space between a cross—an arrangement corresponding with the rood-beam on the south side; and nearly under the arch was the ambo, from which the gospel was read. The choir of the canons was a wooden structure in the nave.

In the churches of Bethlehem, St. John Studius, Constantinople, in Asia Minor, and Syria, we find the basilican form. At Athens there is a very ancient church in ruins, apsidal, and with three lateral distinct naves (those on the sides being designed probably for women), an area, and central fountain. In Asia Minor the Byzantine style exhibits one class of domed buildings resembling St. Sophia, and a second like a modification of a basilica, as at Pitzounda (probably built by Justinian), St. Clement Ancyra (slightly later), and Hierapolis. In the former the circular buildings found detached at Pergamus and Trabala are incorporated, forming eastern lateral apses. Pergamus church (fourth century) was an aisleless basilica, with galleries, eastern apse, transept, and two round buildings, one on each side of the transept, serving for a tomb-house, a sacristy, or a baptistery. The same principle may have induced the construction of apsidal ends to the transepts. The Roman basilica of St. Peter, built by Bishop Agritius in 328, forms the central part of the Cathedral of Treves; it is the only remaining example on this side of the Alps. Schmidt has shown that it was a square, divided into three alleys, and with a central apse on the east. It probably had a portico with five doors on the west.

The gradual development appears to have been the following:—First, to remove the inner narthex and the women's gallery, seating the congregation on one plane; and to build apses to the aisles, as at St. Saba, Rome, St. Cecilia, St. John and St. Paul, St. Peter's ad Vincula, and at Torcello. Secondly, to build in front of the sanctuary (as at St. Paul's, Rome) a wall parallel to the principal front, which was the origin of the transept. Thirdly, to develope the apse by prefixing to it a parallelogram, as at St. Apollinaris, Ravenna. Fourthly, the construction of a triforium, like the upper colonnade of the earlier basilicas, with an external wall passage or arcade forming a communication between the transepts and choir, as at St. Sophia at Padua. The font, in Italy, was transferred to the nave in the eleventh or twelfth century from the baptistery, but at an earlier date in Rome. The sepulchral cell of the catacomb formed the model of the memoriæ, or funeral chapels;—the tomb of the dead was the first altar, the catacomb the earliest church, at Rome.[22] "I was accustomed," says St. Jerome, "to visit the sepulchres of the apostles and martyrs, and often to go down into the crypt dug into the heart of the earth, where the walls on either side are lined with the dead." These catacombs were quarries for furnishing the volcanic sand which forms the subsoil of Rome, and was well adapted to form long galleries; and it is of interest to remember that a common punishment of the Christian was to work as a sand-digger. One of our homilies (Peril of Idolatry, p. 3) says—"Vaults are yet builded under great churches to put us in remembrance of the old state of the primitive church before Constantine."

Wherever a space intervened in the passages closed by a blank wall, lateral recesses were hollowed out for the reception of sarcophagi; the roof was curved like a dome, and the upper part of the tomb was the altar, as in the early church of St. Sebastian. The crypt was known as the martyrdom or confession. It had three arrangements:—First, when a church was built over a catacomb, the old entrance was preserved, as in St. Lorenzo and St. Sebastian, with steps to descend into it. Secondly, if the tomb was on the ground, then a crypt was built round it, and steps were made, while the sarcophagus was replaced by an altar tomb. Thirdly, when a martyr was translated, then the crypt was made to harmonise with the church. In the church of St. Sabina the large stair is in front of the altar, at St. Paul's behind it; at St. Saba's the stairs are in the nave aisles, and the crypt, forming a narrow passage, is reached by corridors, reminding us of the crypt at Ripon. At the Quatuor Coronati, a round stair leads down into it from the benches of the presbytery, as at Torcello, where there is a double wall in the apse. St. Mark's, and St. Praxedes, Rome, have narrow galleries like the passages of the catacombs leading to it; there is a subterranean church at St. Martin des Monts and St. Mary in Cosmedin, c. 790. At Inkermann there is a rock-cut church, apsidal, with square-ended aisles. Rock hermitages occur at St. Aubin (near St. Germigny de la Rivière), St. Antoine de Calumies (E. Pyrenees), St. Baume (Bouches du Rhône), Montserrat, Warkworth, and the Roche Rocks, Cornwall, and in the grotto of Fontgambaud, near Blanc.

In some instances a martyrdom was built like a little crypt, under the altar, with a shrine fenced off by a screen, or perforated marble, as at St. George's, Velabro, and SS. Nereus and Achilles. Sometimes a small hole (jugulum) permitted the head of the devotee to be inserted, or the passing of a cloth to touch the relics. Crypts remain under the eastern apses of Spires, Mayence, Besançon, and Strasburg.

(*To be continued.*)

---

[21] Euseb. Hist. Eccl., x. 4.

[22] *Vide* Gally Knight, *passim*.

INSTITUTION OF CIVIL ENGINEERS.

JOHN HAWKSHAW, Esq., Vice-President, in the chair.

Nov. 27.—The paper read was "*On the Maintenance and Durability of Submarine Cables in Shallow Waters.*" By W. H. PREECE, A.I.C.E.

Referring to an opinion expressed by the late Mr. Robert Stephenson, unfavourable to the durability of Submarine Cables, the author hoped, by detailing his own practical experience in the maintenance of the cable connecting the Channel Islands with England, to elicit a discussion which, by tending to solve that important question, might prove beneficial to the profession, and serviceable to the progress of submarine telegraphy.

The geographical position of the Channel Islands, their rocky and rugged structure, and their exposure to storms, the strong currents by which they were swept, and the nature of the bottom of the sea by which they were approached, were fully described; and it was stated that they were all calculated to try to the utmost extent the qualifications for permanence and durability of a submarine cable connecting these islands with the mainland. The Channel Islands Telegraph Company was formed under the Limited Liability Act, with a capital of £30,000, and a conditional guarantee of 6 per cent. from government. The contract for the whole undertaking was let to Messrs. Newall and Co., who had submerged the cable, constructed the land lines, and handed them over to the company, before the author was appointed engineer. The route and construction of the line, submarine and underground, from Weymouth, through Alderney and Guernsey, to Jersey, and its excellent working condition, were then described. The whole length of submarine cable submerged was 93¼ miles. The length of underground work was 23 miles. The underground work consisted simply of a gutta-percha covered wire, coated with tarred yarn, and laid in a creosoted wooden trough, buried about 20 inches in the ground. The cable comprised two portions—the sea part, and the shore ends. The sea part was a No. 1 gutta-percha covered wire, served with tarred yarn, and protected by ten No. 6 iron wires. It weighed 2¼ tons to the mile. The shore ends were similar, but were protected by ten No. 2 iron wires. They weighed 6 tons to the mile. The line was opened to the public in September 1858.

The interruptions which had occurred to the working of the line, and the plans adopted to remedy the defects, were then successively enumerated. In approaching rocky shores swept by fierce currents, and in landing the ends upon such points, great care was necessary to avoid danger. It was also necessary to protect the cable from detrimental exposure to the surf, spray, and atmosphere. The chief accidents to this cable had been peculiar, and were different to all previous ones with other cables, which were the result of well-known causes. With the exception of one instance these accidents arose quite unexpectedly, without any previous symptom of weakness or decay having been given. Since the submersion of the cable in August 1848, the cable had been ruptured in eleven different places. Two of these accidents were the result of carelessness in landing the end of the cable on the Jersey shore; four were caused by ships dragging their anchors; and five were produced by the abrasion of the slender wire upon the rocky bottom. The accidents arising from ships' anchors took place between Jersey and Guernsey. Those resulting from abrasion occurred between Alderney and Portland. Between Guernsey and Alderney there had not been a single failure. The constant interruptions of this line were attributable to two causes—weakness of cable, and error of judgment in selecting the route pursued.

Although the cable was in the author's opinion too weak, yet he did not attribute the failure of the system so much to that cause as to the route selected. In justice to those who laid the cable, it should be known that if reliance had been placed on the Admiralty charts, there was an explanation of the reason why this particular route had been chosen. But, unfortunately, in describing the nature of the bottom, these official charts were altogether incorrect; as they not unfrequently showed rock where sand was found, and sand and gravel where there were rocks. Cables should, however, never be trusted to the unseen and unknown action of the bottom of the sea without the course having first been most carefully surveyed.

The author next proceeded to point out the oxidation and decay of the cable in different localities; showing how, in sand and mud, when it had become buried it was in perfect preservation, while on rocky ground, where swept by the tides it was being rapidly corroded. The extra difficulty and expense of repairing decayed cables, and the necessity of retaining their strength unimpaired, were adduced as imperative reasons for adopting some outer protecting coating to the present form of submarine cables.

In designing a cable its durability and maintenance should be primarily considered. The present heavy cables were believed to have been erroneously constructed; and it was recommended that in future the outer wires of cables should either be stranded or else be surrounded with two servings of smaller-sized wires.

The plan adopted in repairing the numerous breaks to the Channel Islands cable was then described. The system of grappling, buoying, picking up, &c., having been previously brought before the Institution (*vide* Minutes of Proceedings, vol. xvii. p. 262), allusion only was made to the method adopted in testing, and in calculating the distance and position of faults and breaks. This could now be accomplished with such accuracy that instances were mentioned in which Messrs. Varley, G. Preece, and the author, had indicated the exact spot of faults, though 30, 50, and 60 miles distant. The principles employed in testing were divided into two classes, according as they were dependent upon the laws of resistance or upon the laws of induction. The basis of all resistance tests was the fundamental law of Ohm, expressed by the formula $R = \frac{LC}{S}$, where R was the resistance, L the length of the wire, C the specific resistance of the material employed, and S the sectional area. The advantage of expressing in units of resistance the insulation and conduction of substances was considered. The construction of resistance coils, the various standards of resistance employed by different individuals, and the manner in which one standard could be reduced to another, were described. The instruments employed in measuring resistances—the Differential Galvanometer of Becquerel, Wheatstone's Parallelogram, and the author's Multiplying Differential—were then noticed. By the last instrument resistances could be measured from small fractions to high multiples. From the standard coils attached to it, the resistance of any other standard or any cable could be read, without going through the usual arithmetical calculation. Another system by which much higher multiples could be read was shown.

The laws of induction were next considered, and their various formulæ given, showing how the charges and discharges in different wires were regulated, and could be compared. The basis of all induction was the law expressed by the following formula, $C = \frac{nSRs}{d}$, where C was the induced charge, *n* the battery power, S the surface of the wire, R the resistance of the conductor, *s* the specific inductive capacity of the insulator, and *d* the ratio of the distance between the inside and the outside coatings. The difference between discharge and return current was pointed out. The instruments employed in measuring and registering the discharge were described, including the author's Reduction Inductometer, which could measure the discharge of any wire of any length, from one mile and upwards. The errors that tests were liable to, such as the resistance of ends and faults, and the occurrence of partial faults in different localities, with the plans adopted to detect and allow for these discrepancies, were fully detailed. The various kinds of faults to which a cable was subject were then adverted to.

In conclusion it was remarked that there was no imperfection which could not be detected, and no accident which could not be provided against. But when experience was ignored, and when the errors that had been committed by those who had hitherto had the control of submarine cables were considered, it could not be wondered at that opinions should be expressed unfavourable to the progress of submarine telegraphy.

Annual General Meeting.

GEORGE P. BIDDER, Esq., President, in the Chair.

IN presenting an account of the proceedings during the last twelve months, it was remarked that the principal duty of the Council had been to carry out, and persevere in, the practice and regulations established during previous years, which had been found to contribute so much to the steady growth and increasing importance of the Institution.

On this occasion a short account was given of the state of engineering in a few distant countries, and particularly in some of the British colonies; because those undertakings might not be generally so well known, and because attention had previously been chiefly directed to engineering progress in the United Kingdom, and on the continent of Europe.

At the Cape of Good Hope, a railway, the first undertaking of the kind in that colony, had been commenced, which would run from Cape Town, through Stellenbosch, to the Paarl and Wellington, a distance of about 58 miles. The first section of this line would, it was expected, be opened shortly. At Cape Town arrangements would be made to connect the railway with the harbour works now being carried out, under an act passed by the colonial legislature in 1858. These works comprised a pier or breakwater, running from the western shore of Table Bay, in a north-easterly direction, for a length of 3250 feet, which would provide refuge accommodation, and commercial facilities, at an estimated cost of £400,000. In order to procure materials for the breakwater, which would be formed by a rough rubble mound, a basin was to be excavated having an area of 10½ acres, with a depth of 20 feet at low water of spring tides; and there would be about 4100 feet of quays. An outer basin, 4¼ acres in extent, would be available for the trade, it was thought, in about two years and a-half.

The principal engineering works in progress in Australia were roads, telegraphs, and railways. Telegraphic communication was established between the capitals of the three colonies, and Tasmania had been connected by a submarine cable, which was now unfortunately damaged, between King's Island and the Hummocks. The telegraph wires, which were carried overground, might be seen wherever there were towns, as would be gathered from the statement that there were now 1000 miles in operation in Victoria, about 1000 miles in New South Wales, and nearly 500 miles in South Australia. The railways, with the exception of two or three short lines near Melbourne, all belonged to Government, and had been carried out by means of loans ; the only private undertaking of any magnitude, the Geelong and Melbourne line, having lately been purchased by Government for about £750,000, at par. In South Australia, a proposal had recently been made to inaugurate a fresh policy. Two new railways were projected—a short suburban line, to which it was proposed to give a limited guarantee ; and a more important line, towards which a dotation of land was offered. Unfortunately, a uniform gauge had not been adopted, as it should have been, in all the colonies ; for, whilst in Victoria and in South Australia the rails were laid to a gauge of 5 feet 3 inches, in New South Wales the gauge was 4 feet 8½ inches. This was likely to cause considerable inconvenience in the future, when the main trunk lines to connect the capitals of the respective colonies were completed.

The railways in progress in New South Wales were—1. The Great Southern ; 2. The Great Western ; 3. The Great Northern. The Southern, or main trunk line from Sydney, ultimately intended to join the Victoria system of railways at the river Murray, had been opened as far as Campbelltown, a distance of 34 miles. Up to Paramatta, 13½ miles, there were two lines of way, and beyond, only a single line. A further length of 20 miles, as far as Picton, was expected to be completed in a few months. The cost of the double line, including rolling stock and machinery, and workshops at the terminus, had amounted to upwards of £40,000 a mile, and of the single line about £10,000 a mile. Trial surveys had been made, and estimates prepared of the cost of extending this line to Goulburn, from which it appeared that the natural difficulties were such as would necessitate an expenditure greatly in excess of that hitherto incurred. The Western, starting from the Southern, 1¼ mile west of Paramatta, was opened as far as Blacktown, on the Windsor road, a distance of 8 miles, in August last. The cost had averaged about £10,500 a mile of single line. The works were now in progress up to Penrith, a further distance of 12 miles. This line was at present proposed to be carried to Bathurst, and extensive surveys and explorations had been made of the country between the Hawkesbury and that place, including the valley of the Grose, in order to discover a practicable route by which to pass the range of the Blue Mountains. The Northern Railway started from Newcastle, about 60 miles north of Sydney, between which places there was steamship communication daily. The line was opened two years ago to East Maitland, and subsequently to West Maitland, a distance of 20 miles ; and in August last to Lochinvar, a further length of 8 miles. From Lochinvar to Singleton, 23 miles, the works would be finished in the middle of 1861. The expenditure had amounted to about £12,000 a mile of single line. The country was under survey beyond as far as Muswellbrook, 70 miles. It abounded in minerals, particularly in coal, from which all the Australian colonies, as well as India and China, might be supplied.

In the thriving colony of Victoria, the railways now open were the Geelong and Melbourne, a single line, 40 miles long, passing through a level country, in connection with which there were extensive piers and wharves at Williamstown, the port of Melbourne ; also the suburban railways, which had been constructed by private companies, in whose hands they still remained. These were—1. Melbourne and St. Kilda ; 2. St. Kilda and Brighton ; 3. Melbourne to Richmond, Hawthorne and Brighton ; and 4. Melbourne and Hobson's Bay, a double line, 3 miles in length. The great lines to the interior were—1. Melbourne and Mount Alexander to Castlemaine, Sandhurst, and Echuca, on the river Murray, a length of 152 miles. The main line had been opened to Sunbury, 22 miles, and also the branch to Williamstown. The portion of the line from Sunbury to Woodend, 28 miles, was expected to be finished immediately. 2. Geelong and Ballarat, a length of 53 miles, of which no part was yet open. The estimated cost of these two lines, both of which would consist of a double way, was seven millions (upwards of £34,000 a mile), of which three millions sterling had been already raised and expended. With respect to the general character of the country, it was described as rising regularly from the coast to the dividing range—with the exception of one sudden step of 300 feet—to a height of about 2000 feet in 40 miles. There were occasional chasms, or ravines, 100 to 500 feet in depth, and 660 to 3300 feet in width, through which the water falling on the higher ranges was discharged with impetuous velocity. But there was a total absence of those great leading valleys which were found in England. The larger rivers, creeks, and ravines had been crossed generally by viaducts constructed with abutments and piers of bluestone masonry, and wrought-iron superstructures. The permanent way was of the most substantial character, consisting of a double-headed rail, weighing 80 lb. per yard, fished, and laid in chairs in the ordinary way, on native timber sleepers.

In South Australia a double line of railway, from Port Adelaide to Adelaide, a distance of 3½ miles, had been opened for three or four years, and a single line from thence to Gawler, 29 miles, for two years and a-half. From Gawler to Kapunda, 16 miles, the line was opened this year. It was proposed to extend this line northwards.

The oldest railway in Canada, a short line called the Laprairie and St. John, was opened for traffic in July, 1836. From that period until the year 1849, little progress was made in the extension of railways. At the commencement of 1857 there were 1402 miles of line in operation, and at the present time the mileage was 2093, and the number of railways 15, all which, with one exception, had been constructed between 1852 and 1860. The three principal lines were the Buffalo and Lake Huron, the Great Western, and the Grand Trunk. They ran longitudinally through separate divisions of Canada, and were constructed with a view to secure a share of the large traffic in passengers, goods, and agricultural produce, which found its way from the Western States to the Atlantic seaboard, and *vice versa*. The Welland railway (25 miles long) was constructed two years ago, mainly for the transportation of grain in bulk, and heavy goods, in opposition to the Welland Canal, which had an ascent of upwards of 300 feet of lockage to overcome between Lakes Ontario and Erie. All the other lines depended chiefly upon local traffic. The Canadian railways had nearly all a uniform gauge of 5 feet 6 inches, and were all single lines. The average cost per mile of the main lines had been about £15,000, inclusive of rolling stock and other expenses. The cost of the branches had ranged from £6000 to £10,000 a mile. The bridges were generally built of timber, which it was thought cheaper to renew every ten years than to build at first in stone or iron. But on the Grand Trunk the bridges consisted chiefly of tubular iron girders, and on the Great Western main line there were also some wrought-iron bridges. The capital embarked in Canadian railways amounted at present to about £26,000,000 sterling, of which £4,161,150 might be considered as the contribution of the province of Canada, inasmuch as the interest on that amount (£249,669) was an annual charge upon its revenue.

The only other engineering works constructed in Canada during the last few years, were the deepening and improvement of the river St. Lawrence, between Montreal and Quebec, the erection of lighthouses in the Gulf of St. Lawrence, and works for the supply of water to Quebec, Montreal, and Hamilton.

During the past three or four years there has been great stagnation in the extension of railways in the Northern and Western States of America. In Michigan, the Grand Trunk (of Canada) had constructed 55 miles, and the Great Western (of Canada) had contributed largely towards the completion of the Detroit and Miliwaukie Railway, 186 miles in length. The other American railways in progress at present in the North-Western States were all westward of Chicago, and had all the common object in view of opening up new territories west of the Mississippi and Missouri rivers.

In Russia, the St. Petersburg and Warsaw Railway was commenced, as a Government undertaking, about the year 1851 ; but in 1856 it was ceded, with others, to the Grand Russian Railway Company. The length of this line was about 670 miles, one-half of which was completed, though many of the works were merely temporary. A branch to connect this line with the Berlin-Königsberg Railway was being vigorously pushed forward, and the portion to the Prussian frontier was already open for traffic. The Riga-Dunaberg Railway, 140 miles long, running from Riga towards the producing districts, and by its junction at Dunaberg with the Berlin and Warsaw Railways, connecting Riga with the network of European railways, was rapidly approaching completion, the earthworks and permanent masonry having almost all been completed before the close of the last season. The Moscow and Nijni Novgorod line, which would connect the western ports with the extreme European end of that vast empire, by means of those important thoroughfares for goods, the rivers Kama and Volga, was making rapid progress, and one-half of this line was expected to be ready for traffic next summer.

The improvements which have been made in the iron manufacture during the last few years, and the changes that were now taking place were then referred to; and it was stated that the result had been that whereas the annual "make" of a blast furnace in the year 1750 was only about 300 tons, now it ranged from 5000 to 10,000 tons per annum; and in a few cases amounted even to 15,000 tons per annum. In reference to wrought-iron it was said that the plan of reversing the rolls had been considerably extended, and occasionally a second pair of rolls was placed close to the first, running continuously in the opposite direction, so that the iron could be rolled either in coming forward or in going back. Plates 1¼ inch thick, by 3 feet wide, and 20 feet long, and plates 4½ inches thick, by 3 feet wide, and 15 feet long, had been rolled, as well as bars up to 72 feet long. Most of the improvements in the manufacture of steel had been introduced within the last half-century. Cast steel bells, weighing 53 cwt. each, had been made in this country, and castings of steel weighing 100 cwt. in Austria. Large plates and very heavy bars had also been made of puddled steel, produced direct from cast-iron; and lastly, steel wire, when hardened to about a deep blue temper, was found capable of carrying 130 tons per square inch. More than one process had been used in the production of cheap steel, which had been found by recent experiments to possess nearly double the strength of ordinary iron, accompanied by other valuable properties. With regard to the applications of iron, a new era commenced with the construction of the Conway and Britannia bridges; as the elaborate experiments made prior to their construction tended to prove that previously received theories were in some respects erroneous. Again, the building erected for the Great Exhibition in 1851, from its lightness and security, called attention to the hitherto undeveloped capabilities of the combined use of cast and wrought iron for such purposes.

The improvements in the artillery and projectiles of the present day, which had resulted from the efforts of civil engineers, were calculated to lead to important changes in modern warfare. Simultaneous with the rapid advance in the destructiveness of weapons of offence in attack, there was a necessity for a corresponding alteration in the means of resistance. These subjects had led to elaborate researches and experiments for ascertaining the best qualities of metals to resist the enormous strains and concussions which had to be encountered, and the best dispositions in which to employ them. Iron-coated ships had for some years been regarded as a probable coming necessity; but it was not until about the end of the year 1858 that the Admiralty for the first time seriously considered the subject. This resulted in the designs on which the Warrior and Black Prince were now being constructed. The problem was one of great difficulty. An enormous weight of armour had to be added to the weights hitherto carried. At the same time greater speed was demanded, and that involved increased weight of engines and a larger supply of fuel. Then again, the weight was top-weight and wing-weight, which had to be carried on fine lines for speed. To reconcile these conditions with the practical points in a war vessel, and to give such a ship good seafaring qualities, to make her a good cruiser, and also well suited for a voyage, and for the probable conditions that would attach to an European war, was a problem which might well employ the professional skill of naval architects, and of every member of the Institution.

The principal papers read during the session were then noticed; and it was remarked that there were still many important executed works, some even possessed of great novelty, which had not yet been brought forward at the meetings. It was hoped that accounts of these undertakings would still be brought before the members. The intense interest which the discussion upon Mr. Longridge's paper "On the Construction of Artillery" excited, was referred to. On this occasion Sir William Armstrong and Mr. Whitworth—members of the council—each exhibited a 12-pounder gun on his system, described its mode of manufacture, and explained its working; and the council thought that both of these gentlemen were entitled to the best thanks of the members.

It was stated that the library was now occupying the attention of a committee of the council, with a view to ascertain what was required to render it as complete a collection as possible of works on engineering and the allied sciences, as well as of books of reference on general scientific subjects. The members were urged to assist in procuring copies of all treatises, reports, and documents relating to professional matters; as this was the natural place for their reception and preservation, where they could be consulted by all. At the same time steps were being taken to have completed the set of the Ordnance maps of the United Kingdom, and to procure copies of the maps illustrating the geological survey of the British Isles, and the trigonometrical survey of India. Endeavours were also being made to obtain copies of the reports of all the different railway companies, as such a collection would be, it was believed, of great interest and value.

The deceases during the year were:—William Alers Hankey, honorary member; William Blackadder, Terence Woulfe Flanagan, Col. William Nairne Forbes, B.E., Robert Grundy, Joseph Locke, M.P., Charles May, Joseph Miller, Thomas Penson, Robert Berthon Preston, John Geale Thompson, William Francis Isherwood West, and Francis Mortimer Young, members; Capt. William Fullarton Lindsay Carnegie, R.A., Lieut. Edward Fraser, B.E., Robert Hughes, James Wardrop Jameson, William Sayce, William Sims, and Archibald Slate, associates.

The resignations of one member and five associates were announced. The number of members of all classes now on the books was 930, being an effective increase in the year of 36.

By the death of Mr. Locke the Institution was deprived of the services of a valuable and influential member, who was most solicitous to do all in his power to advance the common interests, and to maintain the dignity and social position of the profession. The suddenness of his removal while in the enjoyment of apparently sound health, and following so immediately after the deceases of his friends Brunel and Stephenson, tended to render this loss even more severely felt.

The abstract of accounts showed that the receipts for subscriptions and fees amounted to £2550, and the expenditure to £2100, the outlay for minutes of proceedings being much less than in previous years. There being thus a balance in favour of the Institution, in addition to the £1000 already placed on deposit at the Union Bank, it was thought advisable that an investment should be made, and accordingly £1100 Norfolk Debenture Stock, bearing 4 per cent. interest, was purchased. During the recess the Stephenson and the Miller bequests of £2000 and £3000 respectively had been received. Thus, the funded property of the Institution now amounted to upwards of £12,000, in addition to which there was a further sum of £2000 to be received under the will of the late Mr. Joseph Miller, in which a relative had a life interest.

It was thought that so munificent a benefactor as Mr. Miller deserved some memorial, and it was considered that none more appropriate could be devised than a portrait to be placed on the walls of the meeting-room. The council had confided the task to Mr. Boxall, A.R.A., who would, it was presumed, produce a good picture of their late member.

In conclusion, it was observed that the steady progress which had marked the career of the Institution from its commencement, and the estimation in which it was held both at home and abroad, should induce the members of all classes, by unanimity and energy, and by earnest cooperation, to study to maintain its high reputation, and to increase its sphere of usefulness.

ELECTRO-BLOCK PRINTING.*

By H. G. Collins.

In noticing my inventions commonly known as "Collins' Patents," and now being worked by the Electro Printing-block Company, it will be useless to discuss the advantages derivable from any means of producing or reproducing cheap illustrations; their necessity is universally acknowledged, and is becoming daily more apparent, and any invention which claims to facilitate this object requires no apology for its introduction to the public.

My first patent, dated the 5th March, 1858, is, to use the words of the specification, for "An improved mode of obtaining impressions on an enlarged or diminished scale from engraved plates or other printing surfaces." I will first describe the method of enlarging.

I take my subject, which may be a printing surface of any description, either a woodcut, a steel or copper plate engraving, a stereotype or electrotype block, or a lithographic stone, and, in fact, any surface capable of giving off an impression; and then on a sheet of vulcanised india-rubber, covered with a composition possessing equal elasticity, and of a non-porous character, I take the impression in transfer ink: if from stone, at the lithographic press; if from steel or copper plate, at the copper-plate press; and if from surface-block or type, at the type press. I then punch small holes at equal distances (generally ½-inch) round the rubber, into all of which I insert hooks of the same size. I connect them by means of four bars passed through the body of these hooks, and thus the sheet is ready for the expanding machine. This consists of two parts, the table and the screw. The table is composed of slate, perfectly even, and mathematically true; round it is a sort of raised shelf for the four bars before mentioned to rest upon, and is divided into inches, half-inches, quarter-inches, and eighths. I place the sheet of rubber, with the hooks and bars round it, square upon the frame, then take the screw, and after duly fixing it, I extend the rubber equally in all directions till it assumes the required size. I test the accuracy of the extension, from time to time during the operation, by measuring the distances between different marks printed on the sheet for that purpose when in an unextended state, and I adjust the tension until I find that the distances have all been increased in the same ratio. The impression on the rubber being thus enlarged, I transfer it to a prepared surface of stone or metal, which is then printed in the usual mode of litho or zinco-graphy. When the amount of extension required is greater than can be well obtained at one operation, which is generally limited to four times the area, it is only necessary to repeat the process.

For reducing, the operation is simply reversed. I extend the rubber first to the original size of the work to be reduced, then take the impression; after which I release the sheet from the tension, which then necessarily assumes its original dimensions; it is then put upon stone or metal, as before described, in the same manner as the enlarged subject, and printed in the usual way.

It is as well to mention that the india-rubber, in order to extend equally, must be made of an uniform substance in every part, for the old axiom must here prove true—that the same thing under the same circumstances must always produce the same result; and it will be obvious that the slightest variation in this particular would materially detract from the perfection of the process; for if any portion should be thinner than the general character of the sheet, that portion must of necessity possess greater yielding power than the remainder, and thus produce an inequality, and a consequent error in its mathematical proportions; and although this slight difference might not signify for ordinary works, such as landscapes, or general illustrations, it would totally preclude the adoption of my invention for maps and plans, or any matter where accurate scale would be indispensable. This perfection in the rubber has not been obtained without great cost of anxiety, time, and money, as in my first steps I was not sufficiently acquainted with the wonderful mysteries of its nature, and consequently was unable to furnish the manufacturers with all the conditions required, the knowledge of which has only been obtained from pure experiment and closely calculated results; and I am happy to say that at length all these difficulties have, through the kindness and assistance of the various india-rubber manufacturers, especially Messrs. Silver, of Silvertown, been entirely surmounted.

With respect to the composition with which I coat the face of the sheet, I may mention that without it the rubber would not give off the impression to the stone: in fact the ink would be entirely absorbed. It is simply a transfer surface, involving the one necessary condition of equal tension with the rubber, or it would crack when extended, and destroy the picture. It is composed generally of flour, treacle, starch, white lead, and gelatine, and when reduced to the consistency of cream is applied with a brush, and allowed to become quite dry before being used.

---

* Abstract of a paper read before the Society of Arts.

It was offered as a suggestion, whether the usefulness of the invention would not be materially increased were I able to obtain the enlarged or reduced impressions on surface blocks to print at the type press. Producing them on stone was not all that could be wished; for, where a great number of copies are required, the expense and tediousness of working from lithography would in many cases be an insurmountable difficulty. After a series of experiments I succeeded in this respect, and hence my second patent, dated October 2, 1858. This invention has for its object improvements in the production of blocks or surfaces to be used in printing. For these purposes the drawing or device is obtained on a block or surface to be used in printing from a drawing or device on a lithographic stone or other surface, whether the same has been produced thereon by hand, transferred, or otherwise, by subjecting the drawing or device on the lithographic stone or other surface to a series of processes similar to that in which a lithographic stone is inked when about to be printed from in the ordinary way, but the ink or composition used is to be mixed with suitable driers, so that each succeeding coating of the composition may quickly dry or set before the next coating is applied. By these means the lines and parts constituting the drawing or device on the stone or other surface, which would be inked and printed from if used in the ordinary manner, become more and more built up or raised; and when such raising has been sufficiently accomplished, a cast in wax or other suitable material is taken, from which an electrotype is obtained, as is well understood.

I do not, however, confine myself to this method; much depends on the character and quality of the work. In many cases, after obtaining the transfer on stone or zinc, instead of building up the picture by successive rollings, I eat away the surrounding part by acid, taking care that the transfer is made in ink that will resist the action of acid and of the galvanic battery, or that it be rolled up with a varnish possessing the same qualities. For fine work this second method is much more satisfactory.

This is the *modus operandi* of my process for enlarging and diminishing maps, plans, and engravings on to the stone, and likewise for making surface blocks therefrom. The manipulation is easy and devoid of all intricacies, when once practically understood. From these two patents have sprung several valuable adjuncts. The first, and perhaps most important, is the production of the electrotype block from the artist's original drawing without the aid of the engraver. I simply require the artist to make his sketch on transfer paper in transfer ink, or if he prefer it, in transfer ink upon a grained metal plate; and this, when delivered into my hands, I roll up with the acid-resisting composition, and then submit to the process before described for making surface blocks from the lithographic stone.

I have also succeeded in making transfers on to stone from most old prints and typography, which may be enlarged or reduced to any size, and made generally into electrotype blocks.

Photography and many other valuable processes in connection with the illustrative art are now engaging my attention, and I have no doubt that in a short time I shall be able to produce an electrotype block from a photograph in the course of a few hours.

THE METROPOLITAN RAILWAY.

This engineering work, which is now making great progress, has hitherto been erroneously designated by the press the "Underground Railway," by which term it might be understood that the line, when completed, would be almost a continuous tunnel from end to end. This, however, will not be the case; for in all cases where old property has been purchased for the formation of the railway, there will be open cuttings, and where the stations occur, they are planned, with their various platforms, to be perfectly open to the daylight, and in many instances their lower level will not be more than 20 feet below the surface of the present roadways, and thus the whole line will be effectually ventilated.

This line commences at the Great Western Railway terminus, Paddington; and will end at Finsbury-circus, City, the total distance being 4½ miles. There will be six intermediate stations, viz., at the Edgeware-road, Baker-street, Portland-road, Gower-street (for Euston-square), King's-cross, and Smithfield. The distances between the first three stations will be about half-a-mile in each case; from the Portland-road station to that in Gower-street, three-eighths of a mile; from thence to King's-cross, three-quarters of a mile; from this to Smithfield, 1¼ mile; and from Smithfield to Finsbury-circus, five-eighths of a mile. The stations will be substantial, handsome buildings, in the Italian style. The platforms will average 200 feet in length, and 10 feet in width. These platforms will be protected overhead by segmentally formed arches of brickwork, while the tunnelled portions of the line will be roofed by arched work of elliptical section, 28 ft. 6 in. in span, constructed of six 4½-inch rings of brickwork, set in hydraulic lime, and Portland cement where required.

As would be expected in the formation of a railway through a large inhabited city, great difficulties of a constructive nature have occurred, which, however, as far as our observation has gone, have been successfully combatted by the engineer. The contractors are Mr. John Jay and Messrs. Smith and Knight, the former having undertaken the distance from Euston-square to the termini at Smithfield and Finsbury-circus, and the latter the portion from Paddington to Euston-square.

The difficulties to which we refer consist principally in the formation of good foundations, the obstructions caused by sewers, drains, water-pipes, gas-mains, &c., which have been dealt with specially according to the circumstances as they occurred. Some of the sewers have been carried over the line in tubes, others under the line, and some are diverted. Generally, however, as far as this portion of the work has proceeded, the sewerage will be much improved. The whole of this department of the work is examined by, and executed to the satisfaction of, the General and Local Boards of Works.

In the formation of the foundations for the line at the west-end, yellow clay occurred in great quantities near the surface, then gravel more or less fine, afterwards fine yellow sand, with a considerable quantity of water, and at the lower stratum blue clay. At the east-end the stratum is nearly all London clay, intermingled with the usual layers of cement stone, very little water occurring. The change in the character of the strata takes place about Euston-square. Concrete is used to a certain extent in the formation of the foundations, and the rails and sleepers will rest on gravel ballast. The permanent way will be constructed of the mixed gauge, to take either broad or narrow gauge rolling stock; the rails, which will be of a similar character to those on the Great Western Railway, will rest on longitudinal sleepers.

In the words of a contemporary, "the Metropolitan Railway will form a direct passenger, goods, and parcel communication from Paddington to the City, and no doubt when fully in operation will ultimately very much relieve the street traffic of omnibuses, cabs, railway-vans, and other vehicles, that at present in a great measure choke up Oxford-street, Holborn, Newgate-street, Cheapside, and the Poultry."

The works were commenced in January last, and it is calculated that the line will be opened in the spring of 1862. The cost per mile will be about £250,000. The engineer-in-chief is Mr. John Fowler, F.R.S., and Mr. T. Marr Johnson is the resident engineer.

REVIEWS.

The Elements of Mechanism: designed for the Use of Students of Applied Mechanics. By T. M. Goodeve, M.A., Professor of Natural Philosophy in King's College, London. Longman. 1860.

This work is an elementary text-book of the principles of mechanism, and contains a very large number of examples of mechanical contrivances, exceedingly well illustrated and described. In the perusal of Mr. Goodeve's treatise we have been frequently struck by the skilful arrangement of the diagrams, and the apt words by which he has contrived to make clear the operations of complex mechanism. The reader who is fond of mechanical contrivances will find abundant opportunity of gratifying his taste in these pages. For our own part, the perusal of them has frequently excited a feeling of wonder at the apparently unlimited means of varying motion in almost every conceivable way. It is almost impossible to select instances, so multifarious are the contents of this work; but we may perhaps, without injustice to the author, mention the accounts of the conical pendulum of Siemens, the use of the ratchet in sawing machinery, and the friction drilling machine of Mr. Whitworth, among the more interesting subjects of this book. The mathematical investigations are few and studiously simple; among them, the investigation of Watt's celebrated parallel motion is as clear and satisfactory as any we have ever seen.

Perhaps the descriptions are occasionally too brief. The work is evidently designed with a view to portions of it being written out by students in examinations; the style is accordingly extremely concise, and the work requires to be read very carefully to be understood. We should have been pleased also to have seen more frequent notice of the history of the progress of the science of mechanism. For instance, in describing such contrivances as Hooke's joint, Watt's parallel motion, or Lord Stanhope's system of levers for the printing-press, it would add to the interest (and as we believe to the value) of the work to refer briefly to the dates and circumstances of those inventions, the manner in which they were published to the world, the degree of improvement which they effected, and (where the case admits of it) the nature of the successive developments of the inventions, and their latest improvements. Another suggestion which we offer for a new edition is the addition of a brief preliminary account of what has been well called the science of "kinematics," which is an equivalent term for Mr. Goodeve's "geometry of motion," and investigates the relative motions of different parts of machinery due to their form, apart from physical considerations. It seems rather hard on the student to require him to master investigations of the relative linear velocities of the parts of a cam (Art. 17), or the relative angular velocities of the parts of contrivance for converting circular into reciprocating motion (Art. 46), without first defining linear velocity and angular velocity.

It is one of the great merits of Mr. Goodeve's work that its descriptions include mechanical inventions of all ages, from the contrivance of the early Greek astronomers to represent the moon's motion, to the latest improvements in the printing-press, boring machine, spinning machinery, and steam-engine. It would be a charity to the numerous tribe of inventors who waste their time and money in re-inventing the same mechanical contrivances over and over again, if they could be compelled to study this work. They would learn that the science of mechanism, like other sciences, as it progresses becomes more and more exact, and therefore that its development is continually less and less dependent on the isolated efforts of inventors, however ingenious, who are ignorant of the existing state of the science.

On Heat, in its relations to Water and Steam: embracing new views of Vaporisation, Condensation, and Explosions. By Chas Wye Williams, A.I.C.E.—London: Longman. 1860. [Second notice.]

The first section of this book treats of the three different states of water. The author, in entering upon the interesting subject of heat in its relation to water and steam, endeavours to define briefly but clearly the chemical, physical, and dynamical properties of those liquids. The conditions in which we find water are three, viz.—the solid, as ice; the liquid, as water; the gaseous, or æriform, as vapour or steam. The chemical constituents of water in these three different states are the same, with the exception of the ingredient heat, which varies in quantity. This equality however does not prevail with regard to their respective physical and dynamical properties. In its solid state we observe a close adherence and immobility of the particles with respect to each other: in the liquid state, although the different particles exercise a strong attraction towards each other, the cohesive power is resolved, and *immobility* of the atoms with respect to each other is changed to *mobility*. In both the above cases, the particles as well as the whole mass is subject to the force of gravity. In the third or gaseous state, however, properties of quite an opposite character to those of the former, make their appearance. The particles or atoms do no longer cohere nor attract each other, but display a general tendency of *repulsion* or *divergence*. They no longer obey the power of gravity, but that of elasticity, a force dependent on and originating with their change to the state in question. This feature is peculiar to all elastic fluids, and in fact distinguishes them from liquids in any other state. It forms the ground of inquiries of the most extensive character, and has given rise to investigations of the properties of the elastic fluid—Steam.

It is to the properties and changes attending the generation of steam by the application of heat to water that Mr. Wye Williams has devoted the greater share of those experimental researches in which his book abounds, and which were undertaken by him with the view of elucidating that which has hitherto been either doubtful or inadmissable under the head of established laws. To enable the reader to judge for himself of these valuable elucidations, we shall extract a few passages and experiments especially interesting and original.

Mr. Williams, in directing his attention to the phenomena of Vaporisation, raises the following questions, to which, as he says, no writer as yet has given satisfactory answers:—

> "1st, What is vapour? 2nd, How and where is it formed? 3rd, What are its special properties? 4th, In what does it differ physically and dynamically from water? 5th, What are the relative proportions of latent and sensible heat in either? 6th, What relation has it to electricity?
>
> All assume that the statements of those who profess to have examined the subject were based on well-defined and accurate experiments. The various modes, however, in which the process, and even the term vaporisation has been described, have in no small degree complicated the subject, and manifestly suggest the necessity for further inquiry. Had writers concurred in adopting any one theory of vaporisation there would have been less room for misgivings. When however we find scarcely any two agreeing, even on elementary points, this alone is sufficient to raise serious doubts as to whether any have given a true account of the process.
>
> Strictly speaking, vaporisation means the single process of converting atoms of a liquid into those of vapour. Numerous instances might here be given, not only of the misapplication, both of the term and the process, but of the confounding it with others; in particular, with that of evaporation. Turner says, 'Vaporisation is conveniently studied under two heads—ebullition and evaporation. In the first, the production of vapour is so rapid that its escape gives rise to visible commotion in the liquid; in the second, it passes off quietly.'
>
> That vaporisation cannot be studied under either head is evident, seeing that vapour may be formed without ebullition or any visible commotion whatever; and as to rapidity—that being solely determined by the rate at which heat is absorbed by the liquid—as much vapour will be generated, in any given time, by the same quantity of heat, whether with or without ebullition. In contradiction to this statement then, it may, *in limine*, be broadly said, that neither ebullition nor evaporation have any immediate connection with vaporisation."

Vaporisation of a mass of water by heat may be effected in two ways. The one by bringing the heat in contact with the surface, and the other by applying the heat at the bottom of the body of water. In order to illustrate the process of vaporisation in its simplest form, Mr. Williams gives the following illustrative experiments:—

"Let *a a*, fig. 1, represent the surface-stratum of the water in a glass beaker.

Fig. 1.

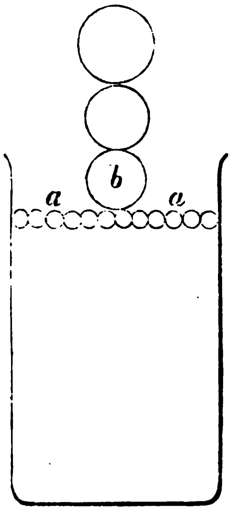
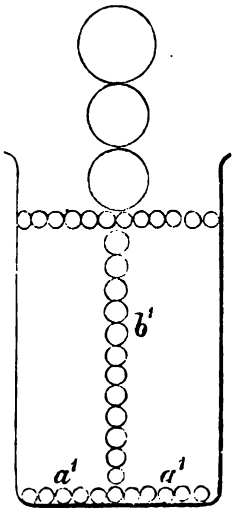


Fig. 2.



Here each atom is necessarily in absolute contact with the air above it, and held in its position by the mere force of gravity and attraction to its

> fellow atoms. Let b represent one of these atoms, after having received its complement of heat, and, becoming vapour, rising in the air as a balloon from the ground. Its volume in this case will continue to be enlarged as it ascends, and as the balloon would, in the ratio of the diminishing density and pressure of the atmosphere in the upper regions.[*]
>
> In fig. 2 let, a' a' represent the carpet-stratum of liquid atoms, and b' one of them, on becoming vapour rising to the surface as a cork would—its volume being enlarged under the influence and in the inverse ratio of the density and pressure of the liquid medium through which it had to pass. It will now be seen that it could only be on reaching the surface that it would be in a position corresponding with b in fig. 1, and be enabled to develop its full volume.
>
> The ratio of the enlargement of the atom b', fig. 2, while in the water, may approximately be estimated by reference to the gross enlargement of the mass. Dr. Ure estimates this at 1-25th of its liquid volume. Dalton's calculation gives a less increase.
>
> Having considered the process as regards individual atoms, let us now examine it in reference to the several succeeding strata, rising from the bottom as they successively become vaporised. These carpet-strata cannot rise in unbroken masses, as a carpet would from the floor, seeing that no atom can rise, *mero motu*, but only as contiguous and heavier atoms take their place, and force them upwards, as Dr. Ure expresses it. The necessary result is that each of these lower strata breaks into sections, and rises in detached portions and forms. This is fully corroborated by their appearance as seen rising through the water, if looked at across the light, or when a lighted taper is observed through the mass. At first, wave-like forms will be perceived moving across the bottom, and then rising through the body of the water with a cloud-like appearance, as in fig. 3. These will continue visible until the agitation, caused by ebullition, disturbs the uniformity of their motion. They may, however, be distinguished, even after 212° has been reached, if the process be carried on gradually and without ebullition, or internal commotion, as will hereafter be described.
>
> It is here worthy of note, and in proof of the necessity of further inquiry, that these movements, although so palpable and suggestive, do not appear to have been recorded, or even noticed by any of the numerous experimenters from Black or Leslie down to the present time. Several other important but hitherto unnoticed movements will hereafter be pointed out.
>
> The first tangible proof we have of the formation and absolute existence of vapour will be its appearance above the surface. The new-formed vapour having passed upwards through the liquid mass, whatever may be its depth, may be caught and condensed on a mirror or dial glass. (A little cold water placed in the dial will prevent its becoming heated, and thus favour the condensation.)
>
> While the vapour continues to rise and escape into the air, we also find the temperature in the mass increasing so uniformly as to justify the inference of its diffusion under the Daltonian law.
>
> Attempts were made, by the aid of an experienced optician, to have those cloudy vaporous forms magnified and projected against a large surface by the magic lanthorn; they were, however, found to be so transparent that the object was defeated. Their visibility was a mere optical effect arising from the different densities of the vaporous cloud and that of the colder water, the rays of the light being refracted from their upper convex surfaces."

As a proof of the rapid formation of vapour the author gives the following illustration, which may be easily exemplified by actual experiment. If heat be applied to a glass beaker filled with a certain quantity of water, vaporisation will be going forward. In order therefore to determine approximatively its extent, Mr. Williams places a concave glass cup filled with cold water upon the top of the beaker. As soon as vaporisation has commenced the cloud-like vapours, as they disengage themselves from the mass of water from which they are generated, will be seen almost immediately to be condensed, and in the shape of drops on the underside of the dish or cup, from which they will finally again drop down into the water below. To illustrate still further the effect of vaporisation and the homogeneous temperature of its action, a second dish or cup, but of a lesser concavity, may be placed over the first one, when a double process of vaporisation, but with equal rapidity, will be observed. The cold water in the lower cup will assume the same temperature as that due to the vapours issuing from the larger body of water in the beaker beneath it; and vaporisation will take place in a similar way, which may be observed by the formation of condensed vapours on the underside of the upper glass dish.

Before concluding the chapter on vaporisation, the author adduces further proofs that it is *vapour*, and *not heated water*, that is seen rising through the water; and proves further by a simple experiment the diffusion of vapours through a large space, but generated in a short time. The next section treats of *The diffusion of vapour and other elastic fluids.*—Before Mr. Williams proceeds to any experiments explaining these properties of vapour, he deems it necessary to give the student a correct view of the principles which influence the different processes in connection with the communication of heat to water, and its results. He explains in an excellent manner how far we are justified in calling the vapours of water an *elastic fluid* in the ordinary acceptance of the term elasticity. The analogy between vapours and other elastic fluids, their expansive properties, and the mutual repulsion of their particles, is here at great length discussed. While on these questions, and on the nature of *mixed gases*, Mr. Williams does not omit to acquaint us with the views of other experimentalists on the phenomena of the diffusion of vapours—phenomena which have required the rigid inquiry of the most gifted men for their solution. It was reserved for Dalton to solve their true nature. Dr. Henry, his biographer, says:—

> "It is impossible to peruse the essay on the constitution of mixed gases, and especially to contemplate the plate by which it is illustrated, without perceiving that meditation on the constitution of homogeneous and mixed elastic fluids had impressed his mind with a distinct picture of self-repellant particles or atoms. Thus he affirmed that homogeneous elastic fluids are constructed of particles that repel each other with a force decreasing directly as the distance of their centres from each other, and as a necessary sequence that the distances of the centres of their particles, or which is the same thing, the diameters of the spheres of influence of each particle, are inversely as the cube roots of the density of the fluids."

In these words, then, we find established the separate identities of the vapour atoms, while in the water, which act but as a liquid atmosphere for their diffusion. A right understanding on this head is of the last importance as furnishing a key to the many disputed and doubtful points which still embarrass the subject. For the ocular demonstration of the repulsion and diffusion of vapours, Mr. Williams gives a series of those diagrams descriptive of the self-repellant particles or atoms which have been so ingeniously delineated by Dalton.

The heating and expanding of water is the next subject taken under consideration. Is water incompressible? The theory promulgated by modern writers on the subject is, that water expands by heat being communicated to it, and admits of a dilation of an almost infinite degree, whilst the compression of which this liquid is susceptible is so little that water may be said to be incompressible. It is a well-known law of nature that all solid bodies expand by an increase of heat being imparted to them, and contract as the heat is withdrawn or diminished. The force with which this alteration in bulk takes place is inferred to be the same, but of an opposite character, to that which is necessary to destroy the relation between the different particles or atoms. Thus, a solid would dilate by the influence of temperature with the same force with which it would resist compression; and again, the same body would contract with a force necessary to tear it asunder by tension. On this Mr. Williams remarks:—

> "This correspondence in force being a general law of nature must be applicable to all bodies; and what are the elementary constituents of a liquid but bodies subject to such general law?
>
> Dilatation and compression are treated as being reciprocal and proportionate. Yet see how a positive law in physics may be rendered doubtful or negative when applied to liquids,—an arbitrary application being resorted to in order to satisfy this theory of expansion, namely, 'The force with which liquids dilate is equivalent to that with which they would resist compression; and as liquids are nearly incompressible, this force is very considerable.' But why not apply the same terms, and draw the same conclusions in both cases, namely, that as liquids are nearly incompressible they must necessarily be nearly inexpansible! Prof. Graham observes:—'Regnault has recently determined the compressibility both of water and mercury with great care, and estimates the compression of mercury for each atmosphere at 3·5-millionths of its bulk, whilst he found that of water to be equal to 47-millionths of its bulk.'
>
> By the above dictum it is sought to be inferred that the resistance to expansion or dilatation, as regards liquids, is not commensurate to that of compression; in a word, that action and reaction are, in this case, not equal and opposite. We shall, however, find more harmony in nature's laws.
>
> If these liquids then be incompressible, *pari ratione*, they must be inexpansible; for if the resistance to compression cannot be overcome, neither can the resistance to expansion or dilatation."

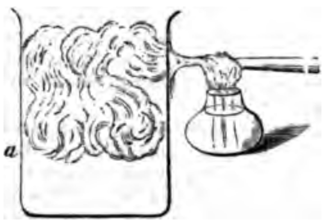
Mr. Williams next considers the influence of *conductibility* and *non-conductibility* on the heating and expansion of water. He points out with great clearness the oversights and errors committed by writers on this question. He convinces us of the misinterpretation of the experiments undertaken by them with the object of arriving at a conviction, and proves that diffusion of heat in a liquid cannot be effected by circulation of the particles, or descending currents, before ebullition has taken place, as has been asserted by others, and sought to be established by an experiment in which the motion of particles of a light and insoluble powder, as amber, which had been deposited at the bottom of a vessel filled with water, were supposed to indicate the descending currents, or the circulation of the particles of the water, by which the former were set in motion. That these lighter particles of a solid substance, however, are merely made to ascend by the vapours which move from the bottom of the water upwards, and to descend by their own gravitation, has been fully shown by Mr. Williams.

---

[*] The circle b here represents, not the atom itself, but the range of the repellent influence it exerts.

With respect to the descending or downward action of vapours, and the non-conductibility of water, and that the former, not the latter property, is the only reason of its homogeneous temperature, we quote the following experiment:—

Fig. 3.



"A large blow pipe was applied to the flame of a gas burner by Herapath's apparatus. The flame was projected against a beaker of water, about two inches in diameter, and made to spread against the glass, as shown in fig. 3. Ebullition soon took place, and the mixed vapour and water were seen rolling over and descending, as here shown. By dipping a thermometer into the water, the line of influence of the hot stratum at *a* was clearly visible. This line may also be seen, in a wave-like form, descending until it reaches the bottom. It is here advisable to cover the vessel partially, to prevent the too rapid escape of the vapour. This may be said to be the process by which the water in marine boilers becomes influenced throughout, and circulation effected, until ebullition has commenced, the mechanical force of which further promotes that circulation."

(*To be concluded in our next.*)

Colling's Gothic Ornaments.——Colling's Details of Gothic Architecture. London: J. R. Jobbins.

We have before us the first numbers of the new editions of these works, which we are glad to see are about to be reproduced in their original serial form at short intervals. When they first appeared, our pages on several occasions noticed their excellence and utility, and as they are still unsurpassed, and will always be valuable works of example and authority, we again recommend them to the notice, as deserving of attentive study, of the younger members of the architectural profession who may be unacquainted with their contents, from their having been out of print for a considerable period.

The whole of this encyclopædic collection of ornament and detail, and the beautiful coloured decoration given in the two works, are delineated to a good scale and from actual measurement, which circumstance renders the plates, some 400 in number, especially valuable.

DISTURBANCES OF THE BAROMETRICAL COLUMN AT CERTAIN SEASONS OF THE YEAR.

At a recent meeting of the Literary and Philosophical Society Mr. Atkinson read a paper on Barometrical Disturbances, in which he stated his conviction that all the movements in the atmosphere of our earth which have received the designation of *irregular* are caused by the reflected or radiated heat of the sun, and take place at a very moderate elevation, say within five or six miles of the general surface level; and that these apparently irregular movements or shiftings from place to place of lighter and heavier air, causing oscillations in the barometric column, are mainly, if not wholly due to irregularities of the earth's surface. Had our earth been a globe possessing a smooth surface of uniform texture and properties, it seems clear that the atmosphere would have been acted upon by the reflected and radiated heat of the sun, in a manner so much in accordance with a uniform sequence of physical effects, that the periodic movements of the gases composing it would have been as regular as the planetary motions themselves. In the northern parts of our hemisphere, it appears by Mr. Baxendell's paper, read before the Literary and Philosophical Society, on the 13th of October last, that the barometric oscillations are least in amount when the sun is on or near the equator. This fact points to the inference that if the plane of the earth's orbit had coincided with the plane of its equator the disturbance of the barometric column would have been comparatively small and nearly uniform throughout the year. The coincidence of these two planes not existing, it is found that as the sun retreats from the equator towards the southern tropic, the sum of the oscillations of the mercury gradually increases for a considerable time, and then rapidly mounts up so fast as to form a prominence in Mr. Baxendell's curves resembling a mountain peak. This peak or summit of the "dynamical curve" occurs above different points of its axis—that is, at different periods of time, according to some peculiarity in the position different from the latitude or the longitude of the locality from which the data for constructing the curves were derived.

Speaking of the northern hemisphere, as the sun withdraws southward from the equator less or greater portions of the northern part of the terraqueous surface becomes cooled down gradually to the freezing point, according to various peculiarities of substance—elevation above the sea-level, proximity to the open ocean, or to far-inland mountain ranges, and to other analogous causes. In similar latitudes, from the varying conditions just mentioned, there will exist, side by side, spots differing, or having a tendency to differ very much in temperature, and where consequently currents of different density—set in motion by the constant struggle going on in the air to attain a state of equilibrium—will cause frequent fluctuations in the barometer. These disturbing causes will, in any region, be much increased at the setting in of winter and the commencement of hard frost; for at this crisis a large amount of latent heat will be liberated, and will contribute its influence to disturb the equilibrium of the air. A similar crisis will occur at the end of winter on the breaking up of the frost, and will necessarily be attended with similar results. As the times of these crises appear to correspond in a remarkable manner with the times of maximum disturbance of the barometrical column, it seems but fair to infer that a relation exists between the causes here stated to be in operation, at the critical periods just named, and the periodical disturbance of the mercury in the barometer indicated by Mr. Baxendell's "dynamical curves." The correctness of this inference, or the contrary, can only be established by future observation of phenomena, and the collection of facts, many of them of a kind seldom thought of hitherto as constituting elements for the solution of problems in meteorology.

METROPOLITAN INTERCOURSE.

It may be as well for the public that, through the City at least, the omnibus tram-lines have been for a time postponed by the passing of a resolution at Guildhall (Court of Sewers), on the 4th ult., to take the subject "into consideration that day six months;" such project, for which the majority of the now crowded thoroughfares are too narrow, would only take the attention from the more legitimate modes of relieving them. Among these we reckon — first, the Thames embankment, which we trust, through the sensible and business-like report of the parliamentary committee, is likely to be put forward in a manner that, besides greatly beautifying, must confer a benefit on the metropolis and its inhabitants for ages to come.

The embankment could be executed down-stream, beginning at Millbank; every length, then, inside one range of floated and ballasted caissons or crib-coffers (as first used perhaps half a century since) could be completed, the embankment, with the esplanade drive upon it,—at least so far as roughing out the tide docks, and taking advantage of the necessary junctions with the streets forming headings to the docks, each length could be made available to the public. The coffers made in lengths could be joined by I terminals trenailed together, forming puddle-chambers below low-water line, but above which they could be caulked: to secure them in their position, besides the permanent ballasting, which, with the water to be admitted when duly ranged, would sink them, they could be secured at certain distances by an occasional pile driven into the bed of the river on their line, with counter or stream piles, outside which would act as "fenders," and to which struts or braces should be attached. These stream piles and the others could easily be drawn or cross-cut level with the bed of the river on the removal of each coffer length, and the trenails in the **I** junctions could be driven back from the inside. Three working lengths of coffering should always be in progress. The first formed to be in occupation by the masons, the second to be nearly ready for them to come to work within, and a third to occupy the pioneer hands, so that the whole work should proceed with the strictest order, and yet be carried on with all possible rapidity. While the embankment, esplanade, and docks would be thus working down-stream, affording great facility to the subsequent formation of the intercepting sewers, the sewers themselves might progress up-stream from below on both sides of the river, and thus not only the four terminals might be kept approaching each other, but in sundry places, as means and convenience might admit, other, even detached portions of the embankment and esplanade might be laid off and proceeded with, should hands to press forward the work freely offer. It is not likely however that more than one-half of the future breadth of the esplanade, with a wide footway next the river wall, could be made available at first on the down-stream working, until the excavation by the intercepting sewers would furnish the remainder of the solid filling required, between the arched entrances into the docks, but the parts worked up from below against the stream should be completed off-hand the full breadth, all deficiency of filling to be supplied by land or water from such places as might then offer.

The second most important work of the kind, as nearest in connection with the City, we may reckon "The Charing-cross and Bank Junction," or twice across the Thames, which has been called the **T T** Railway. The promoters of this line, availing themselves of the facility for tying their rail with the heart of the City, have taken the necessary measures for obtaining an act of parliament, in the ensuing session, to enable them to make their invaluable extension.

At the Surrey side there may be said to exist no difficulty that cannot be easily got over. On the high level the railway, with common prudence, must be run. The river might be advantageously crossed to or opposite Cousin's-lane Stairs; and by removing the block of stores of an inferior class standing between that lane and Dowgate, an ample opening would be obtained, not only for even a double line of railway, to be run on arches over two stories of warehouses and places of business, but for an excellent street, to be continued by the purchase of the west side of Walbrook the whole way, and so widening opposite the St. Stephen's Church of Sir Christopher Wren.

The rents of the lettings under the railway, with such an improved streetway in front of them, would probably pay the entire purchase-money; and a considerable further sum might be expected by a sale to the City, to render it free, of a toll-bridge for carriages and passengers, to be erected with, and be a part of, the railway bridge, which would thus relieve London-bridge, and be of immense advantage to the City, while the thoroughfare to be thus created would alone secure the rents of the lettings alluded to.

The project third in importance, but for which we believe no step has been as yet taken to obtain an act of parliament, would be, as talked of in the West-end, a line of railway to connect the extreme north-west with the south-west of London, which might be called the Paddington to Pimlico Railway.

Proceeding from Battersea railway-bridge on the high level, it would probably pass at a convenient height over the streets immediately south of Sloane-square, near to Brompton-crescent, and at either side of the South Kensington Museum (with the Brompton station there); but as there is a rise of 40 feet from the Brompton-crescent to the Kensington-road, a deep cutting might commence between, so as to pass the railway at a very easy ascending inclination under the Kensington-road, Rotten-row, and the Serpentine water, with probably a shaft carried up, through a hollow and well-shrubbed island, for light and ventilation. It might then pass under the Ring-road and Kensington-garden fence, under the west side of Sussex-square to the Paddington Station, and, passing up its east side, might form a junction with the Metropolitan Railway now in progress from Paddington, by King's-cross, to Finsbury-circus. The only inconvenience or delay that could arise would be but trivial, viz., the backing from Battersea-bridge of the down trains into the Victoria (Westminster) Station, but which, from the peculiar circumstances of level, the safety of the public would require, as well as, perhaps, an improvement of that junction by an alteration in the old Grosvenor Canal-bridges, under which the line runs, and raising of the rail so as to obviate the present inconveniently-sudden, if not dangerous, dip the railway takes to enable the train to clear the soffits of the arches.

The last, and by no means the least important communication to be considered, is that over Blackfriars-bridge, and the propriety of sanctioning any attempt to replace the failing arch of that structure. As there is a rise of 16 feet in the roadway of the bridge, rendering it inconveniently steep, the opportunity might be taken of getting rid of half the rise, and so giving the road an easy inclination.

◆

THE NEW GRAVING SLIP, CRONSTADT.

A correspondent, writing from St. Petersburg, informs us that the powerful graving slip erected at Cronstadt for the Russian government, by Mr. H. Grissell, of the Regent's Canal Iron-works, has just been brought to a successful completion.

The dock or slip has a rising incline of 1 in 24 from the mole upwards, for a length of 800 feet. Six lines of rails, with a central rack for hauling, of immense solidity, are laid down to carry the cradle, which contains 200 tons of oak and iron in its construction. The chains with which the cradle is hauled up with its load, consisting, perhaps, of a ship of 2000 tons register (for which it is calculated), consist of two distinct sets of alternate long and short links of rectangular section, each link containing in transverse section 10 inches of the best malleable iron. The holes for the connecting links are all accurately bored to a gauge, and the pins for the connection are of steel, turned expressly so as to fit with the greatest precision. The hydraulic apparatus patented some time since by Mr. Miller, of Glasgow, is employed as the moving power; it has a working stroke of 15 feet, corresponding to the length of the winding-up chains, or traction bars. The ram has a diameter of 14 inches.

The supply of water to the apparatus is obtained by three pumps, worked by a 40 horse-power horizontal engine, which also drives a horizontal capstan for the purpose of hauling up the empty cradle at a greater speed than could be obtained by the hydraulic apparatus.

On completion, the cradle and machinery were subjected to a severe trial by way of proving their efficiency, a species of caisson being erected upon the cradle, and loaded with 1200 tons of ballast. This load was lowered into the dock with the greatest facility, and drawn up again as a navvie would wheel a barrow. Our correspondent states that "not a screw was loose, and the links appeared to connect and disconnect themselves by some automatic process." During the trial the cradle was brought to a stand to a sixteenth part of an inch. A series of trials were satisfactorily terminated by placing upon the cradle and hauling up, through ice three inches in thickness, the Vladimir, the well-known mail packet running between Cronstadt and Stettin, an iron paddle vessel of large size.

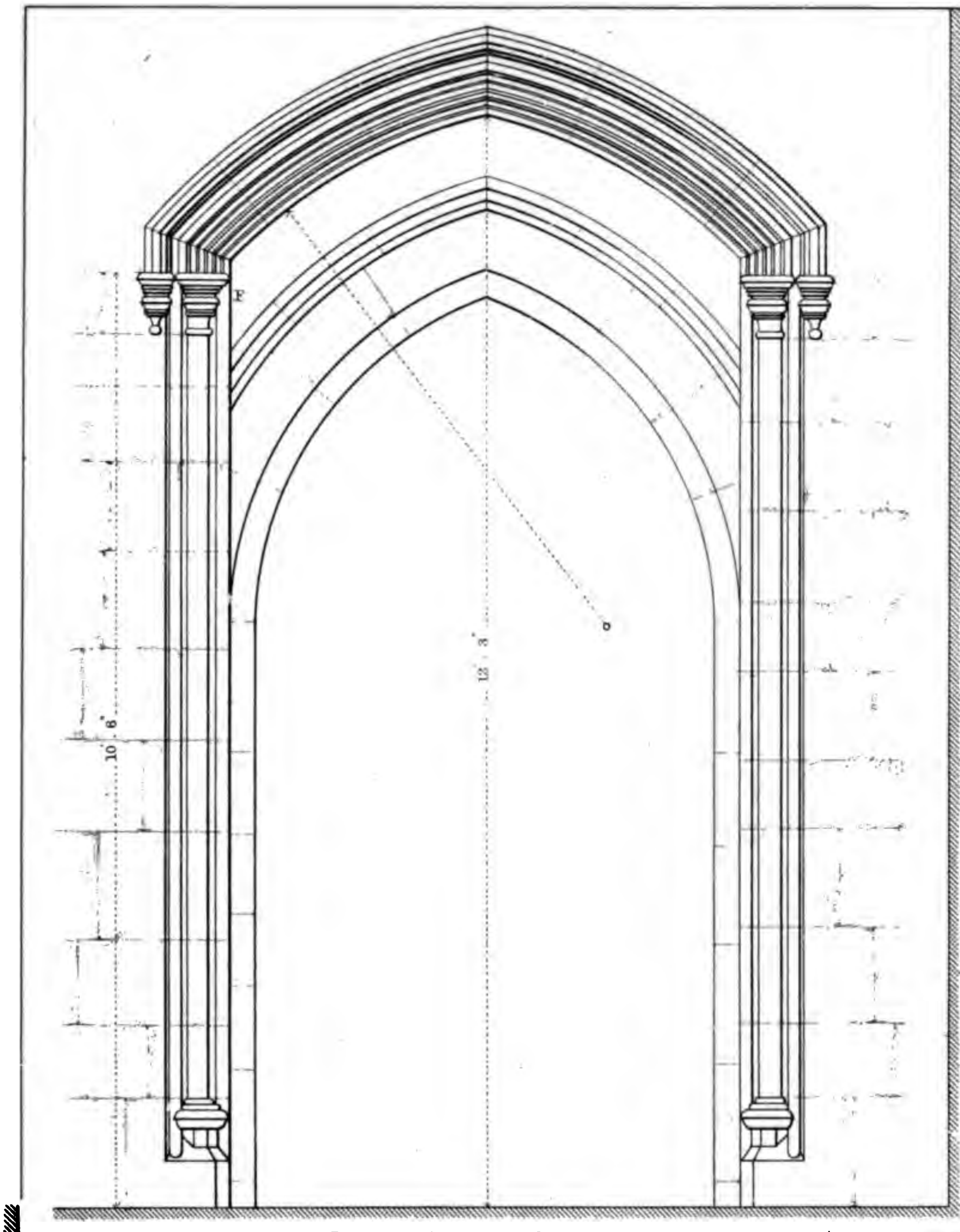
The works have been carried out by Mr. Alfred Cooke, A.I.C.E., formerly resident engineer for the Crystal Palace, Sydenham, and who was also engineer, under Mr. Grissell, for the lighthouse erected in the Baltic, on the island of Seskar.

Lubricator.—At a recent meeting of the Franklin Institute, Mr. J. E. Wootten exhibited a model of Andrews and Carr's patent lubricator for car journals or other end bearings. It consists in introducing the oil for lubrication into a chamber formed by boring a cylindrical hole into the end of the axle, of a depth about equal to the length of the journal. A small hole is bored from the surface of the journal to communicate with the chamber, and through this orifice the oil reaches the bearing. A tube for containing oil fills the chamber. Upon the insertion of this tube with its charge of oil, the chamber is closed by means of an annular screw-plug, in which is inserted a disc of plate glass, which serves the admirable purpose of affording an opportunity of observing at a glance what quantity of oil the chamber contains, and when the supply should be replenished. Experimental tests which have been made with this lubricator, show it to be very economical and efficient in its performance.

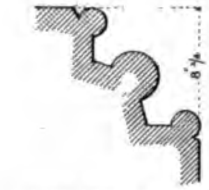
COMPETITIONS.

Designs are invited, with estimates, for a commodious hotel, at Saltburn-by-the-Sea, in Cleveland, for the Stockton and Darlington Railway Company. Premiums, £50 and £30. A sketch of the ground may be obtained by application at the railway office, Darlington. Designs to be sent in, with estimate, by the 31st inst.

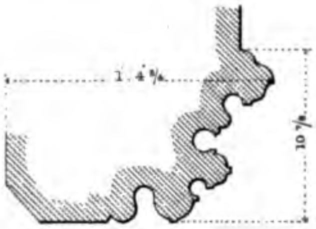
Plans and estimates are required for the erection, at Bury St. Edmund's, of a new corn exchange, with butchers' shambles. The materials to be iron and glass, as far as may be considered practicable for such a building. A ground plan of the site may be obtained on application to the town clerk. Plans to be sent to William Salmon, town clerk, by the 10th inst. Premiums, 25 guineas and 10 guineas.



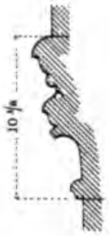
Interior Elevation. S.W. Doorway



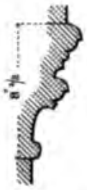
Arch Mould at E



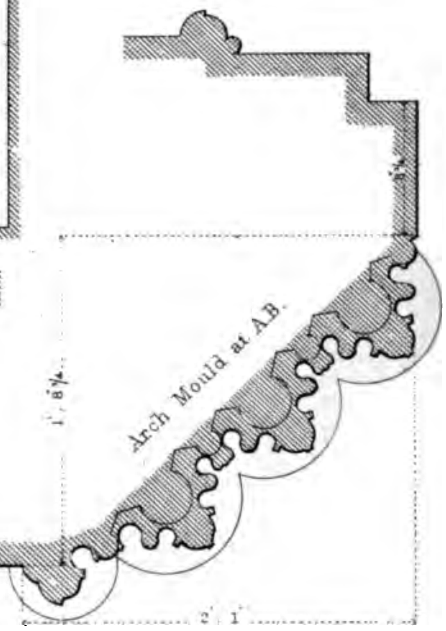
Arch Mould at D.



Capital at C

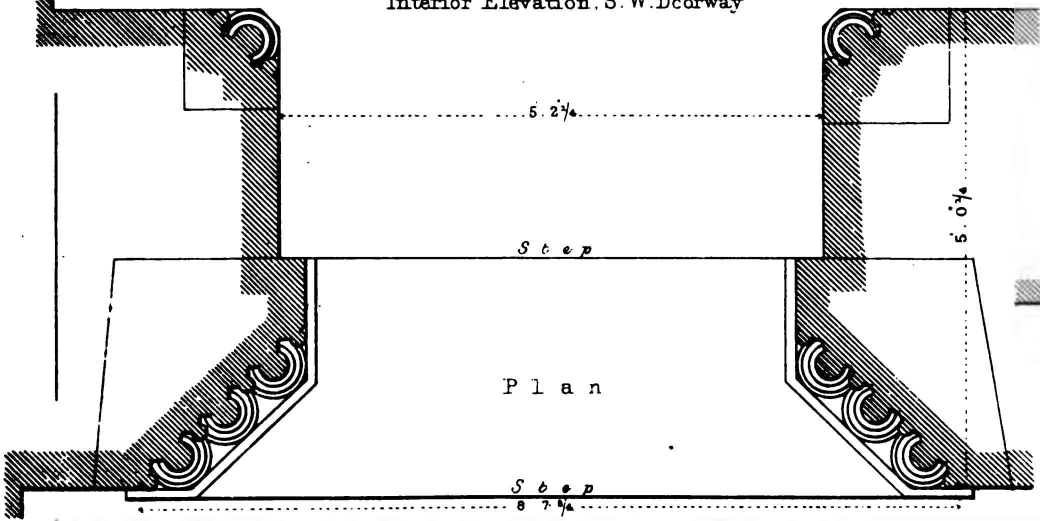


Capital at F.

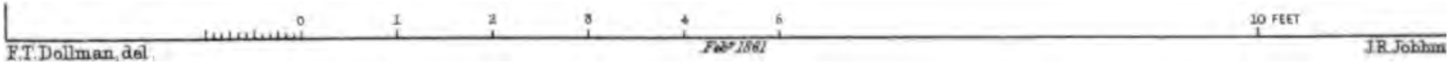


Arch Mould at A.B.

Scale of Details
1 Inch to a Foot.



Plan



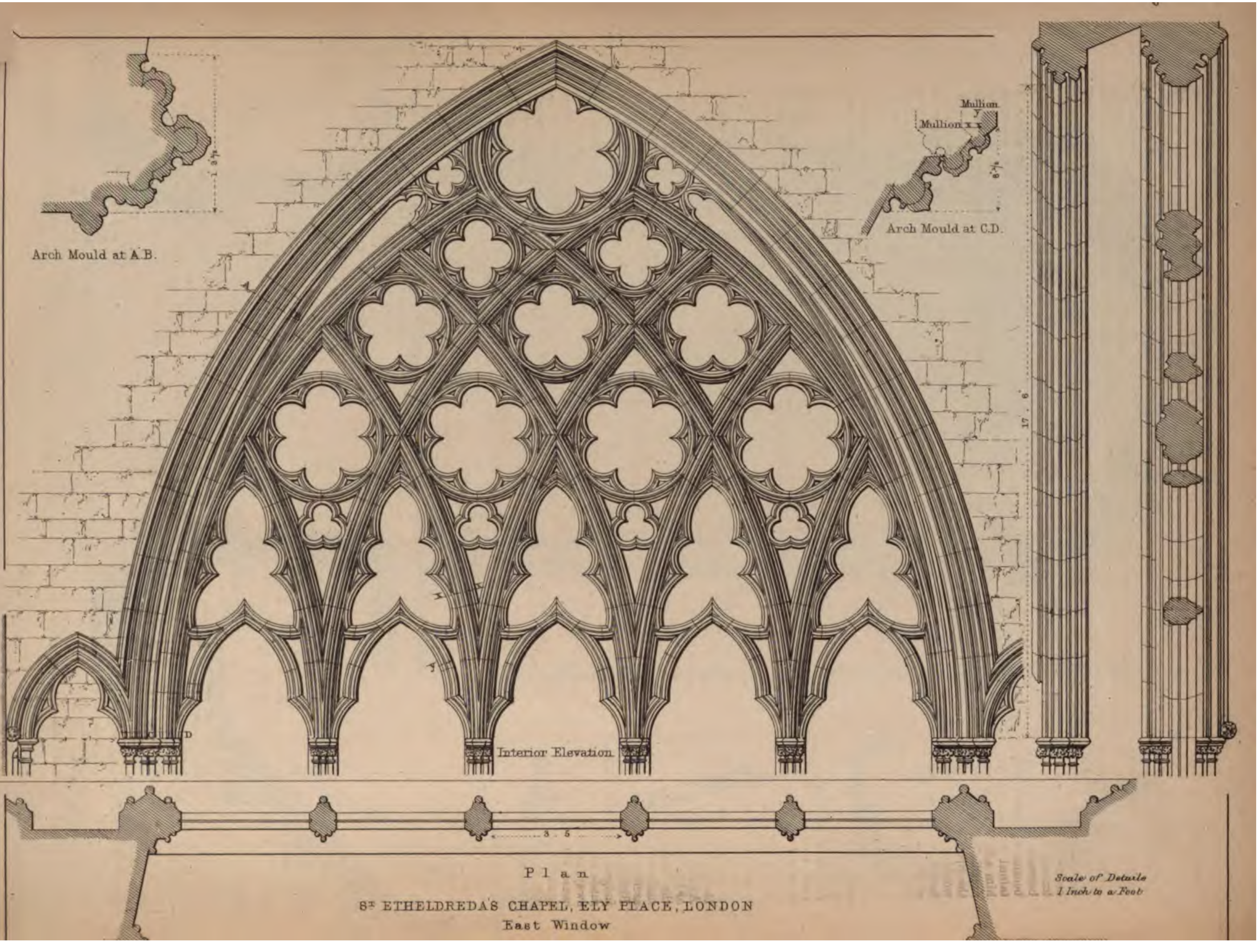
F.T. Dollman, del.

Feb 1861

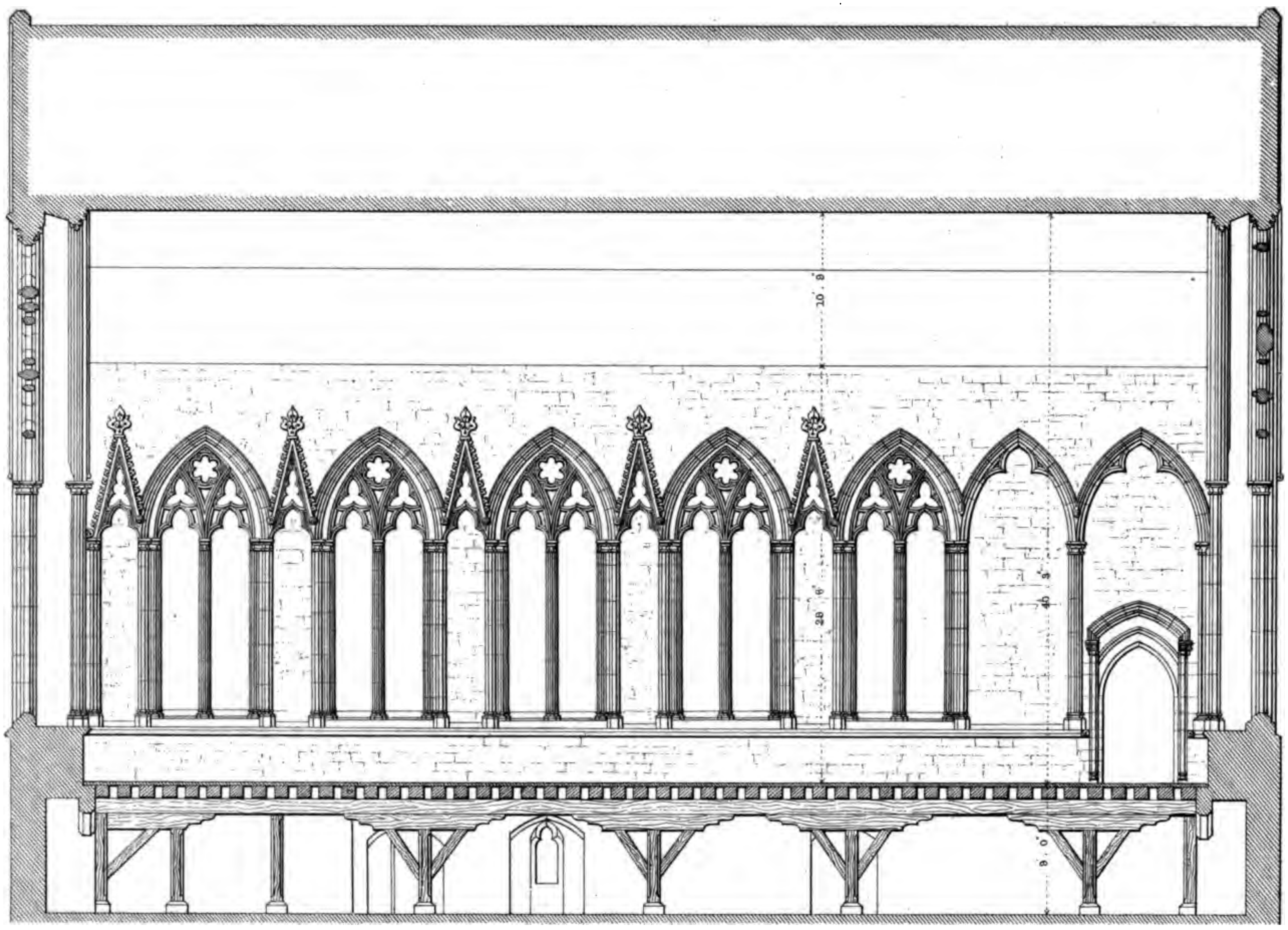
J.R. Jobbin

ST ETHELDREDA'S CHAPEL, ELY PLACE, LONDON

Interior Elevation & Details of South West Doorway.



S^T^ ETHELDREDA'S CHAPEL, ELY PLACE, LONDON
East Window



Longitudinal Section, looking South

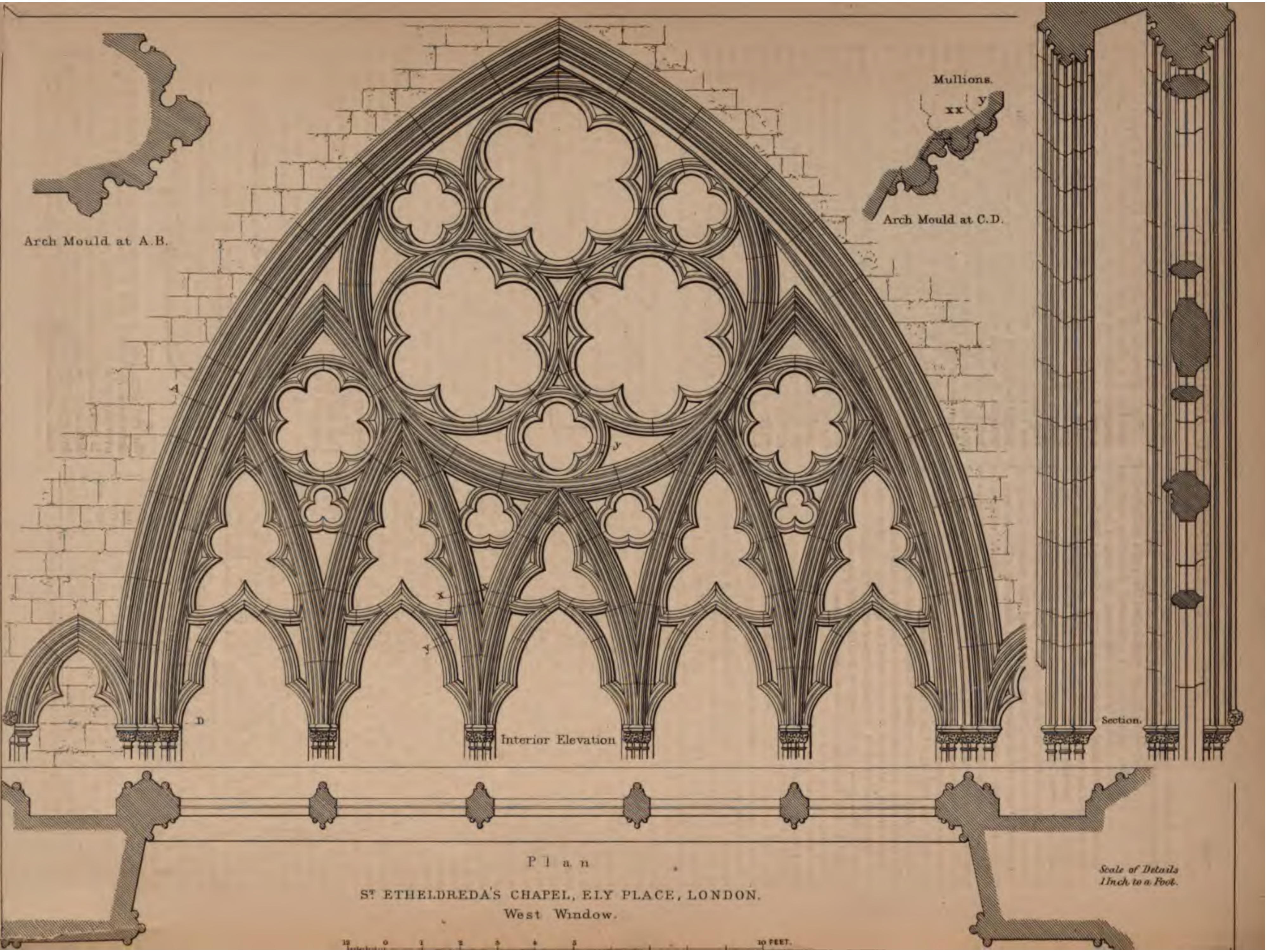
ST ETHELDREDA'S CHAPEL, ELY PLACE, LONDON.

Note. *The Cills and Bases of Shafts to the Windows are nearly conjectural*

F.T.Dollman, del.

March 1861

J.R.Jobbins.



S^T^ ETHELDREDA'S CHAPEL, ELY PLACE, LONDON.
West Window.

HISTORY AND DESCRIPTION OF ELY PLACE, HOLBORN.

(*With Engravings.*)

RESUMING the history of Ely Place, we note that Sir William Newport, Sir Christopher Hatton's nephew, and whose surname he adopted, became, on his uncle's decease, possessor of the estate; and after his death, his widow, the historically well-known Lady Elizabeth Hatton, after a lengthened rivalry between her two suitors, Lord Bacon and Sir Edward Coke, became the wife of the latter, for whom in time she entertained so deeply rooted an aversion that she finally refused him admission to her house. Howell, the author of 'Londinopolis,' states in one of his letters, that Count Gondomar, the Spanish ambassador, told the king that "My Lady Hatton would not suffer her husband, Sir Edward Coke, to come in at her fore-door, nor him (the Count) to go out at her back-door;" this strange woman having refused Gondomar, who was her immediate neighbour, a passage through her back-gate into the fields.

It was about this time, *i.e.*, in the reign of James I., that the last representation of a religious "mystery" in England took place at Ely House, on the night of a Good Friday, the subject being Christ's Passion; and thousands, it is said, were present. In the succeeding reign of Charles I., the grand masque by the four Inns of Court, in which Whitelock, Hyde, and Seldon took part, was arranged at Ely House. This performance was a species of preliminary rehearsal to its performance before the king and queen at Whitehall, on Candlemas Day, 1634. The cost of this magnificent pageant is said to have been £21,000.

Lady Elizabeth Hatton died on Jan. 3, 1646, having to the last resisted any reconciliation with her husband, and every attempt on the part of the Bishops of Ely to recover the property. During the period, *i.e.* from 1609 to 1619, that the good Bishop Lancelot Andrews, who was translated in 1619 to Winchester, held the see of Ely, some efforts had been made to redeem the mortgage, and the bishop expended £2000 in repairing the portion that still remained unalienated. Bishop Matthew Wren (uncle of the great architect Sir Christopher Wren), who had been chaplain to Bishop Andrews, made an offer of the money, and obtained judgment against Lady Elizabeth Hatton, but this decision was made in adverse and troubled times—the Long Parliament held sway, and Bishop Wren, a man of unshaken loyalty to the king's cause, who, with others of his episcopal brethren, had protested against their ejection from the House of Lords, and all proceedings of the House during that exclusion, was in consequence impeached, and subsequently confined in the Tower for upwards of eighteen years. Meanwhile a resolution was passed which set forth that the estate of Lady Hatton, being good in law, was not redeemable in equity, nor subject to the said pretended trust. During the bishop's imprisonment the palace was dismantled, a great part pulled down, and the well-known garden became the site of the present Hatton-garden; part of the palace and offices were used as a prison and hospital, so that on Bishop Wren's reinstatement in 1662, not only was the habitation entirely desolate, but he had lost nearly all hope of ever being able to restore the palace to its original purpose. A law-suit was however commenced, which finally resulted in one of his successors (Bishop Simon Patrick) consenting to accept a fee-farm rent of the value of £100 per annum as a compromise.

Among the most noteworthy events that occurred at Ely Place after the Restoration, we find that on November 14, 1668, the then Dean of Ripon, Dr. Wilkins, was consecrated Bishop of Chester in the chapel of the palace, when Dr. Tillotson, Archbishop of Canterbury, Dr. Cosin, Bishop of Durham, the Bishops of Ely, Salisbury, and Rochester, officiated, the Archbishop preaching the sermon. Here also, Susanna, the daughter of Evelyn the historian, was married, on the 27th April, 1693, to William Draper, Esq., by Dr. Tenison, then Bishop of Lincoln, and afterwards Archbishop of Canterbury.

At the time of Prince Charles Edward's defeat by the Duke of Cumberland, in 1746, an incident occurred in the chapel of Ely Place, which has thus been mentioned by the poet Cowper in the 'Task':—

> "So in the chapel of old Ely House,
> When wand'ring Charles, who meant to be the Third,
> Had fled from William, and the news was fresh,
> The simple clerk, but loyal, did announce
> And eke did rear right merrily two staves,
> Sung to the praise and glory of *King George*."

Subsequently to the middle of the eighteenth century, when all hope of recovering the property that had been granted to Sir Christopher Hatton was abandoned, the condition of the palace became increasingly desolate,—the buildings were by degrees pulled down, the chapel, the hall, the cloisters, and some other portions excepted, and the chapel was subject to the grossest desecration, the space underneath being used as a public drinking cellar, whence the sound of noisy and profane revellings actually proceeded during the hours of divine worship. The bishop's horses were brought through the hall, for want of a better entrance, and the palace, which Stow had sometime declared to be "large and commodious," was reduced to a very dark and incommodious habitation, the bishops being obliged to enter the apartments reserved for their use by the back way. Several cellars under their private apartments were let to other tenants, and the windows and passages of these cellars opened into the cloisters. Sir Thomas Gooch, D.D., who was Bishop of Ely from 1747 to 1754, was the last who fitted up Ely House as a residence. He died there on Feb. 14, 1754, and in 1762, on the death of the last Lord Hatton, the entire property, which during the long period of nearly 500 years had been a place of episcopal residence, and the scene of the most magnificent displays,* was finally disposed of. An act of parliament was obtained in 1772, under the episcopate of Bishop Keene, whereby, the bishop consenting, all the rights and property connected with Ely Place were transferred to the crown for the sum of £6500, with an annuity of £200 to the bishop and his successors for ever. Out of this £6500 the sum of £5600 was appropriated to the purchase of Clarendon or Albemarle House in Dover-street, Piccadilly, with other messuages and gardens, to be settled on the see, subject to a reserved rent of £18 a year,—the remaining money, with £3600 due from the executors of Dr. Mawson, Bishop Keene's predecessor, for dilapidations, was applied to the erection of the house in Dover-street, called Ely House, which was settled on the Bishops of Ely for ever.†

For some time it was uncertain what would be done with Ely Place. A convenient excise office was required, and the ground on which the palace stood was suggested as eligible, but its situation was objected to. The project of removing the Fleet prison was also entertained, and again Ely Place was under consideration, in consequence of the amount of ground still attached to it, but the inhabitants of Hatton-garden petitioned against the erection of a prison on that spot, and the parishioners of St. Andrew's, Holborn, and the Earl of Winchelsea (to whom estates in Hatton-garden belonged, and who feared that thereby his property would be injured), also gave the scheme all the opposition in their power; the bill brought into the House of Commons did not in consequence succeed. A scheme was also set on foot for converting it into a stamp office, but this also failed. The estate was finally re-sold by the crown to Mr. Charles Cole, crown surveyor, when the hall, cloister, &c. were removed, and the present street, also called Ely Place, was built on the site. The chapel however escaped demolition, and after passing through various hands, having among the rest been purchased and presented to the National Society by Mr. Joshua Watson, for the use of the children of the central school in Baldwin's-gardens, an arrangement which was afterwards given up, it has been of late years a place of worship for Welsh episcopalians, and divine service is celebrated every Sunday in the Welsh language.

The foregoing particulars are a summary of the principal historical facts connected with one of the most interesting features of Mediæval London.

In this practical age—"the age of iron," as it may literally be termed—an adequate conception of the dignity and magnificence which distinguished the palaces of the clergy and nobles in London can be with difficulty realised, a few scattered and dilapidated remains being all that now attest the departed glories of the ancient residences. Among the most distinguished was Ely Place, but of its original aspect before Queen Elizabeth's

---

[*] During this time there had been forty-one Bishops of Ely, of whom six had died within its walls.

[†] The originals of the plan and three views of Ely Palace as it stood in 1772, from which the illustrations given by Grose and other authors have been engraved, have been kindly lent to the writer of this account of the palace, through Mr. B. Ferrey, architect, by the Rev. Edmund Keene, son of the munificent prelate of that name to whom allusion has been already made, and regarding whose liberality Pennant writes the following:—"It was the fortune of that munificent prelate, Edmund Keene, to build or repair more ecclesiastical houses than any churchman of modern days. He bestowed most considerable repairs on the parsonage house of Stanhope, in the bishopric of Durham,—he wholly rebuilt the palace at Chester,—he restored almost from ruin that at Ely,—and finally, Ely House, Dover-street, London, was built under his inspection."

reign, when, according to Strype, it had "grounds consisting of an orchard and pasture, all inclosed within a wall," and, as already stated, comprised within its boundaries an extent of upwards of twenty acres, no accurate record, it may be feared, remains. Towards the end of the last century, Grose, the historian and antiquary, describes the then existing buildings (A.D. 1774) as follows:—

"This house stands on the north side of Holbourne, almost opposite to St. Andrew's Church. The entrance is through a large gateway, or porter's lodge, into a small paved court; on the right hand are some offices supported by a colonnade, and on the left a small garden, separated from the court by a brick wall. In the front appears the venerable old hall,[*] originally built with stone; its roof is covered with lead. Adjoining to the west end are the chief lodging rooms, and other apartments. The inside of this hall is about 30 feet high, 32 broad, and 72 long. The timber of the roof forms a semi-dodecagon. It is lighted by six Gothick windows, four on the south, and two on the north side. The floor is paved with tiles. At the lower end is an oaken screen, and near the upper end there is an ascent of one step, for the high table, according to the old English fashion. To the north-west of the hall is a quadrangular cloister, its south side measuring 95, and its west 73 feet. In the centre is a small garden. The east end is at present shut up, and has been converted into a sort of lumber-room or cellar. Over these cloisters are lodging-rooms and galleries, where are several antient windows, but not above two small pieces of painted glass, and those neither beautiful nor curious. Adjoining to the north side of the cloister, in a field containing about an acre of ground, stands the chapel. This field is planted with trees, and surrounded by a wall; on the east side, next the hall, are the kitchens. Here were several other offices, which have been taken down within the memory of persons now living. The exact time when this chapel was built is not known; it is dedicated to St. Etheldreda; and is a right-angled parallelogram, in length 91 and breadth 39 feet, having at each angle an octagonal buttress or turret, crowned with a conical cap or pinnacle. The east window is large and handsome; on each side of it, as well as of those on the north front, are niches with pedestals for statues. The ornaments seem to have been carefully finished, but the whole building is at present greatly defaced by time and weather; the inside is still very neat, and seems to have been lately repaired. The floor is about 10 or 12 feet above the level of the ground, and is supported by eight strong chestnut posts, running from east to west, under the centre of the building. This forms a souterrein or crypt, the size of the chapel, having six windows on the north, answering to as many niches on the south side. At present several of the windows are stopped up. The entrance into this place is through a small Gothick arch under the east window. It does not appear that there ever were any burials in or under the chapel.

The buildings of this house have undergone many alterations, repairs, and additions, as appears both by the different stiles of architecture, and the various materials with which they are patched. By whom these were done is nowhere mentioned, except in the life of Bishop Launcelot Andrews (in Bentham's 'History of Ely'), where it is said that bishop laid out two thousand pounds in the repair of Ely House, Holbourne, Ely Palace, Downham Hall, and Wisbeach Castle. This was between the years 1609 and 1619."

It has sometimes been asserted that the chapel was erected during Bishop Arundell's episcopate, viz., between the years 1374 and 1414;[†] but the most cursory inspection is sufficient to show this is an error, the date of its architecture clearly belonging to the beginning, and not to the end of the fourteenth century. It is throughout of Geometrical Decorated character, and a truly beautiful example it has been. In plan it is a parallelogram, measuring 80 ft. 3 in. long by 29 ft. 5 in. wide, and about 50 ft. high internally. The original entrance was at the south-west angle, and in the jamb-mould of this doorway are three shafts, with moulded capitals and bases, and intermediate smaller shafts; and the arch above the springing has a series of exceedingly beautiful mouldings. On the inside, the arch of the doorway is segmental pointed, concentric with the outer arches, and the jambs have shafts with moulded caps and bases, the label-moulding being carried on a moulded corbel at the level of the springing of the arch. The whole of this doorway, with its details to an enlarged scale, will be found on Plates V. and VI. It is probable that at the western end was an ante-chapel, and that a screen originally existed between it and the chapel. The two westernmost compartments, instead of windows on the north and south sides, had mural arches. The chapel had five 2-light windows on the north and south sides, the windows being connected by a wall arcading, which, above the springing of the arches, had crocketed and finialed canopies slightly projecting from the wall, and filled with geometrical tracery.

The east and west windows are of large dimensions. Each has five lights; the west window being considerably the better of the two in design. In the tracery of the east window the sub-arcuation is not concentric with the outer arch, whereby a species of spandril space is somewhat awkwardly obtained at the top of the window; and it has been attempted, but not very successfully, to obviate this defect by the introduction of a sexfoil circle and other tracery in the space referred to. The original ceiling of the chapel may probably have been the same form as at present, viz. polygonal, in four bays; an inspection of the roof, as far as it was practicable, above the ceiling indicating no signs of moulded or ornamental work; while the quatrefoil openings in the east and west gables present no appearances of having been glazed, but were probably for the purposes of light and ventilation only, and intended to be concealed from view from within the chapel.

According to the drawings of the year 1772, the same arrangement of windows and intervening arcading as that on the inside appears to have existed exteriorly, but the lower portion of the window openings appears to have been blanked up. The windows on the north, east, and west sides, lighting the souterrein, were of two lights, and, like the rest, of Geometrical Decorated date. On the south side of the crypt, in the interior, were two recesses, apparently aumbryes, and two single-light openings, formerly looking into the cloisters adjoining; the north-west octagonal turret in all probability contained a staircase, the door of which was in the crypt.

The foregoing description of St. Etheldreda's chapel cannot well be concluded without some notice of the existing state of the building, for, since Grose wrote, great indeed has been the change: the modern Ely Place has superseded even the remnant of the palatial dwellings that existed in 1772. Hall, cloisters, dwellings, gardens, have disappeared, and all that now remains is the once magnificent Chapel of St. Etheldreda,—itself, too, changed in all respects, and now occupying a retiring position behind the frontage of the houses in the street. In the interior, the pewing and galleries, "altar-piece," and pulpit (the portentous sounding-board of which rears its elevated head in the very midst of the building) presents a most incongruous and unsightly mass of carpentry and joinery. An upper gallery almost entirely obscures the design of the tracery in the west window, an accurate restoration of which could only be obtained by access to the outside through the houses in Hatton-garden. The tracery in the windows on the north and south sides has been entirely destroyed, the most wretched modern wooden sashes being substituted, and no indication of their original design existed until very recently, when one of the window recesses at the north-east angle of the chapel was opened, and the original tracery, built into the wall of the adjoining house in Ely Place, was brought to light, the tracery indeed in a state of considerable mutilation, but nevertheless sufficiently perfect to indicate the design of the original two-light window. The interior of the entrance door at the south-west angle of the chapel, close to which is a particularly small and inconvenient modern staircase leading to the organ gallery, is now entirely hidden from view by modern wood panelling and jamb linings, with the exception of a portion of the label-mould. When the writer of this account measured the building a short time since, the application of a few tools sufficed to bring to light the interior of the original doorway, which for more than seventy years had remained concealed from view. The interior walls of the chapel are encrusted with an admixture of yellow wash and dirt, and on the outside, from neglect and the effects of a London atmosphere, the masonry is in a melancholy state of decay; the jamb and arch mouldings of the windows are almost wholly obliterated, and nought but a faint indication of the arcading connecting the north and south windows exists. The west front looks upon a small yard within a few feet of the rear of the houses in Hatton-garden, and the east front, towards Ely Place, has been "beautified" and renovated with a facing of stucco, "neatly jointed" with the most careful symmetry. Under the east window, two literally "Gothic," *quoad* barbarous, doorways into the chapel have been inserted. Both the octagon turrets at the east end have disappeared, and those that remain at the west end are mere shapeless masses of masonry. The souterrein or crypt is merely a place of lumber, and a receptacle for casks of all sorts and sizes.

---

[*] According to the drawing of the hall of the palace, it would seem to have been erected in the fourteenth century, and was probably coeval with the chapel, the windows being apparently of Geometrical Decorated character.

[†] Malcolm, in his 'Londinium Redivivum,' vol. ii. p. 237, states—"Thomas Arundell was the prelate who expended the greatest part of his revenues on the palace; and I suppose we are indebted to him for the beautiful but solitary fragment now left for the admiration of the antiquary and man of taste, the product of an architect familiar with the rich fancy of the Edwardian style, fully indulged in the grand east window."

Such was—such is—St. Etheldreda's Chapel. Contrasting its past glories with its present desolation, it is surely not too late or quite in vain to plead with those who are interested in the few remaining antiquities of our gigantic metropolis, for the faithful and thorough restoration of a building so historically interesting, and so architecturally valuable.

◆

SUSPENSION GIRDER BRIDGES.

Prof. Rankine's communications of November 24 (vol. xxiii. p. 351) and December 26 (*ante* p. 4) were each received too near the time of going to press to admit of our appending any comment or acknowledgment. It is satisfactory to find such a degree of general correspondence between the results arrived at by the Professor and those to which we were led in the inquiry published in our November and December numbers. The systems of investigation pursued having been so distinct, this approximate accordance of result possesses considerable interest and value.

Prof. Rankine has rightly given the conditions and the amount of the maximum strain on the suspended girder, according to the method adopted in our article, *previous to the correction for the stretching of the chains*. It will nevertheless be found that, *after this correction is made*, the maximum strain will be that which arises when the rolling load covers half the bridge: or, at least, that this supposition will be close enough to the truth for practical purposes.

We shall be very glad to avail ourselves of the promised opportunity of comparing the details of the investigation of which Prof. Rankine has given the results with our own. In the meanwhile, we confine ourselves to indicating the grounds of the conclusion we have been led to adopt as to the conditions which practically determine the maximum strain.

We will first give a brief sketch of the reasoning on which the calculation of the maximum strain, *irrespective of the stretching of the chains*, is based.

A load equally distributed between the points rs and r_2s, at the rate m per foot forward (amounting therefore to $m[r_2-r]s$), will impose the following strains on the suspended girder, at any assigned point whose distance from the half-span (with its proper sign) is denoted by x:—

Direct strain,

$$=m\left\{(r_2-r-r_2^2-r^2)\frac{s^2}{4}+(r_2+r-r_2^2+r^2)\frac{sx}{2}-\frac{x^2}{2}\right\}=(\mathrm{D})$$

Reflex strain,

$$=m\left\{\frac{25}{16}(r_2-r)-\frac{5}{2}(r_2^3-r^3)+r_2^5-r^5\right\}\left(\frac{s^2}{8}-\frac{x^2}{2}\right)=(\mathrm{R})$$

The actual strain at x will therefore be the difference between these direct and reflex strains, or will be equal to (D)—(R).

For given values of r_2 and r, the position of the maximum strain is found by making

$$x=\frac{r_2+r-r_2^2+r^2}{1-\frac{25}{16}(r_2-r)+\frac{5}{2}(r_2^3-r^3)-r_2^5+r^5}\times\frac{s}{2}=(\mathrm{X})$$

since this gives its greatest value to the expression (D)—(R).

The substitution of the value of x above determined leads us to the following general expression for the amount of the maximum stain on the suspended girder, loaded from rs to r_2s:—

$$\text{Maximum strain}=ms^2\left\{\frac{7}{128}(r_2-r)-\frac{1}{4}(r_2^2+r^2)+\frac{5}{16}(r_2^3-r^3)\right.$$
$$\left.-\frac{1}{8}(r_2^5-r^5)+\frac{1}{8}\,\frac{(r_2+r-r_2^2+r^2)^2}{1-\frac{25}{16}(r_2-r)+\frac{5}{2}(r_2^3-r^3)-r_2^5+r^5}\right\}=(\mathrm{M})$$

This general expression for all maximum strains itself attains its maximum value when $r_2=\frac{1}{2}$ and $r=0{\cdot}08212$, or when about $\frac{5}{12}$ of the girder is loaded, commencing at one end. The principal maximum strain is therefore arrived at by substituting these values of r_2 and r in the expression (M), and will be found to be $(\mathrm{M})=0{\cdot}01655ms^2$.

The greatest strain to which the girder would be exposed if not suspended, under a rolling load at the rate m per foot forward, would be $=0{\cdot}125ms^2$. In terms of this strain, the maximum strain on the suspended girder is expressed by the fraction 0·1324.

The position where the principal maximum strain occurs is found by substituting the above values of r_2 and r in the expression (X), which gives, as the distance of the point where this strain occurs from the half-span, $x=0{\cdot}27025s$.

The amount of load which will be thrown on the chains when the rolling load reaches to within $0{\cdot}08212s$ from the half-span, is found (from the formula given, vol. xxiii. p. 353, col. 2) to be equal to $0{\cdot}37307ms$; and as the portion of the rolling load which we have supposed to be brought upon the bridge will come to $0{\cdot}41788ms$, the chains will carry 0·89 of this load.

Thus far our results do not widely differ from those which Prof. Rankine has educed from our theory. It now remains for us to give our reasons for maintaining that it answers every practical purpose to consider that the rolling load occasions the greatest strain when it covers *half* the span: and that the suspended girder may be made *one-eighth* as strong as a common girder for the same rolling load; adding to this proportion of one-eighth such an allowance as may be due to the stretching of the chains. With this object in view we revert to the example adduced at vol. xxiii. p. 354, col. 1. A bridge of 400 feet span was there instanced, having a suspended girder of such rigidity, that without the assistance of the chains it would carry a distributed load of 50 tons, with a deflection of 10 inches. It was also supposed that the settlement of the chains due to a distributed load of 400 tons would be 4 inches; the rolling load being taken at 1 ton per foot forward, or m being $=1$.

The greatest strain which such a rolling load would throw on a common girder bridge would be $0{\cdot}125ms^2$ or $0{\cdot}125\times1\times400^2=20{,}000$. Call this strain S. The strain on the suspended girder at the quarter-span, when the rolling load covers half the bridge, is one-eighth of S, or 2500, before the allowance for the settlement of the chains. The load thrown on the chains is $\frac{ms}{2}=200$ tons; and the consequent settlement will be 2 inches. This settlement will reduce the reflex strain on the girder by the amount of 500 at the half-span, and 375 at the quarter-span. The net strain on the girder at the quarter-span will therefore be

$$2500+375=2875=0{\cdot}1437\times\mathrm{S}.$$

The theoretical maximum strain when the rolling load covers a length of bridge $=0{\cdot}41788s$, or 167·152 feet measured from one end, is equal to $0{\cdot}1324\times\mathrm{S}=2648$. The load thrown on the chains is in this case $0{\cdot}37307\times ms$, or 149·228 tons. The consequent settlement will be nearly 1½ inch. This settlement will reduce the reflex strain on the girder at the half-span by 373, and at the point of maximum strain (about 108 feet from the half-span) by 264. The net strain on the girder at this point will in this case be therefore equal to $2648+264=2912=0{\cdot}1456\times\mathrm{S}$, which is within 1½ per cent. of the net strain in the former case; and at seasons when the chains are expanded by summer heat, the strain will be decidedly greater in the former case than in the latter.

It would therefore seem that, provided there is no error in our reasoning, it would be sufficiently safe and accurate, where a bridge of one span only is under consideration, to assign to the suspended girder such a degree of strength that it would by itself carry one-eighth of the greatest rolling load, distributed over the entire span, without undue strain; and to add to this proportionate strength such a further percentage as is found to be demanded on account of the stretching of the chains. One word more as to this percentage.

We have already given (vol. xxiii. p. 353, col. 2) a formula for the settlement of the chains of a suspension girder bridge, consequent on an elongation at the rate $1:1+e$. This formula is

$$\frac{25e}{32}\left(\frac{s^2}{4v}+\frac{4v}{3}\right)$$

s being the span and v being the rise of the chains. If s and v are given in feet, this settlement is given in terms of a foot. Having then determined on the proportions of a bridge, and the section and elastic strength of the chains, it becomes an easy matter to reckon the settlement which will take place when the maximum rolling load covers the bridge. Call this settlement d. We can also estimate the deflection of the unsupported girder due to a distributed load equal to one-eighth the maximum rolling load. Call this deflection D; D as well as d being in terms of a foot. Then the flanges of the girder should be strengthened in the ratio of $1:1+\frac{3d}{8\mathrm{D}-3d}$; so that one-eighth the rolling load would now deflect it, not D, but only $\mathrm{D}-\frac{3}{8}d$.

Any further addition of strength to be given to the girder to meet the strain that may occasionally arise from the thermometric expansion of the chains, will be determined by an expression of a similar form to that just indicated. But in dealing with this part of the question regard must be had to climate as well as to the season in which the bridge is fixed, and to the degree (if any) of forced camber given to the girder, after fixing, by tightening up the rods.

We should take an interest in seeing Prof. Rankine's examination of Mr. E. A. Cowper's *tension ribs*. We have ourselves been led to a consideration of the subject, and may take an early opportunity of presenting to our readers an investigation of it, based on the method we have ventured to originate in dealing with the suspended girder.

CONTINENTAL PUBLICATIONS.

In the *Encyclopédie* for October of last year a short article occurs, on the "Preservation of Stone," a translation of which, together with quotations from a letter on the same subject subsequently published, will be found at page 40 of this month's Journal, as it seemed desirable that all relating to so momentous a subject—one probably far more important to ourselves than to our French neighbours—should be distinctly indicated by a separate title.

Another and an interesting document is to be found in the same part of the *Encyclopédie*. It is a report read before the Academy of Fine Arts by M. Duban, one of its members, who had been deputed to examine into the desirableness of establishing a museum of art and manufactures (*d'art et d'industrie*) at Lyons, the centre, as is well known, of the French silk manufacturing district. Notwithstanding the necessarily local character of its object, this document is so interesting, as showing the view taken in France of the position now held by the art manufactures of this country, and of the progress we are making, that it is with some reluctance that we refrain from transcribing the whole. The opening paragraphs are as follows:

> "Gentlemen,—The commissioner appointed by you to examine the report of M. Natalis Rondot, on the utility of forming a museum of art and industry at Lyons, has the honour to lay before you the observations suggested to him by the examination of this document.
>
> During the Universal Exhibition of 1851, the English people, noticing with an attentive eye the industrial movement roused by the competition thus nobly opened to all the nations of the globe, was obliged to admit its inferiority on certain points, especially those where art and taste exert an influence upon industry. National feeling was roused throughout England. That country, with the promptness she always displays in the rectification of all mistakes having a bearing upon her commerce or her supremacy, and with the practical good sense which is to her so safe a guide, immediately resolved to raise her art and taste to the level of her industry; in other words, to place herself in a position to defy any competitive rivalry. A Department of Science and Art constituted with this object, the creation of numerous public schools, a central museum of art and of manufactures, nourishing by special and frequently renewed contributions the museums established in the central towns of the different manufacturing districts, an increase in the number of professors, and the selection of them from the most accomplished men of the day,—such were the first results of a resolve due to the initiative of Prince Albert, and carried out with the characteristic perseverance of our neighbours.
>
> The Universal Exposition of 1855, in Paris, revealed the progress made under this energetic impulse. The spectacle then presented of French manufactures, such as till that day had stood unrivalled, now equalled in certain respects, and even surpassed in certain others, inspired men of forethought with fears for the future of that supremacy which France had so long swayed in these matters. These fears were set forth, along with an indication of the proper mode of allaying them, in an original document submitted for your consideration by the higher administrative authorities.
>
> A remarkable report prepared by your perpetual secretary relative to this work, a competition which you opened on this important subject, and a premium awarded, all testify that from the first this Academy had taken into anxious consideration the future of our art industry.
>
> The city of Lyons, watchful against everything that might threaten that special manufacture which has raised her name to such high consideration throughout the world, was the first to point out this nascent rivalry. Free from anxiety as to the present moment, but with forethought for the future, the Chamber of Commerce of this city, as early as 1856, repeatedly deputed M. Natalis Rondot, its ordinary representative in Paris, to visit England, there to study the institutions recently founded by the Department of Science and Art, and especially the organisation of industrial museums. The result of the observations successively made by M. Rondot, and condensed into the report which you required should be examined—a report read before and adopted by the Chamber of Commerce at Lyons—was a proposal to create a museum of art and industry at Lyons, on the model of the South Kensington Museum at London."

Here follows an account of the kind of museum proposed. It is intended that it shall be a separate establishment, not affiliated to either of the schools or colleges existing in the city, but distinct from them and complementary to them, supplying that information and instruction which it is not in the nature of the other establishments to afford. And the object at heart, the improvement of general taste and the advancement of general progress, particularly in ornamental manufactures, will be best promoted, it is considered, by an institution to be divided into three leading departments of art, of industry, and of history. The art museum is to have its specimens chronologically arranged, and in separate rooms, with a common corridor. These objects are to include all that will conduce to a complete understanding of the character of ornament prevalent at each period of the history of art. "A special library, and a room for the exhibition of flower-pictures of all schools," form part of this division.

The second or industrial department is to comprehend three subdivisions: the first for raw materials; the second for fabrics of silk, and of silk mixed with woollen, cotton, linen, gold, or silver; and the third for the machinery used in the manufacture. The historical department is to give not only specimens showing the history of silk manufacture at Lyons, but also illustrations of all the other manufactures which have at any time flourished there. The list of these include casting, chasing, pottery, coining, ecclesiastical goldsmiths' work, beaten metal work, and printing.

The commissioner, while heartily approving the general plan, adds a suggestion, for which it is gratifying to observe he considers himself as much indebted to England as for the whole scheme. With a view of affording means for the study of colour and of the forms of growth of the vegetable kingdom, he suggests that the innumerable varieties and glorious colouring of exotic flowering plants and the gay plumage of birds, should to some extent be brought within the reach of the students. To quote again from the document—

> "The commissioner ventures to suggest an idea which, if his information be correct, has been partially realised in one of the art museums of England. This idea would be, first, to establish in the city one or more hothouses for the cultivation of such foreign flowers as are suitable to furnish models, and then to appropriate some sections of the intended museum to collections of tropical birds and butterflies.......... It is easy to perceive that the composition of rich fabrics might gain in freshness, brilliancy, and novelty of appearance by the constant examination of the tones, sometimes blended and gentle, sometimes decided and bright, but ever harmonious, the secret of which nature embodies."

The scheme, with this one suggestion, is warmly recommended to the approval of the Academy; and it will almost startle as well as gratify those who read the entire document, to observe the repeated references made to English progress, such as, for example—

> "Even if French industry had not been threatened by any serious competition on the side of England, the art upon which it depends would none the less require, for the maintenance of its rank, the realisation of the projected scheme. But this threatening rivalry should cause all hesitation to cease. Not only at Lyons, but equally at Limoges, at Mulhause, at Rouen, at the centres of industrial districts, but, above all, at Paris, ought the appeal to be heard and the example to be followed."

Again, referring to a free drawing school existing at Paris, it is added, in a spirit not quite in accordance with the high tone just before taken,

> "But this school, enough for the requirements of an industry that reigns uncontestedly and with no fears for its future, might be further developed, and might to a greater extent fortify our intelligent Parisian industry against the unheard-of efforts put forth (*les efforts inouis tentées*) in England."

We are the more gratified by the opportunity of bringing before our readers this testimony to the progress being made in this country in the cause of artistic manufacture, and to the share in that progress due to the Prince Consort, because few public acknowledgements of this sort have as yet appeared. The sins of the Department of Science and Art are most unsparingly laid bare, and none can more heartily condemn their most serious mistake, *i. e.* the choice of a bad situation for the central school, than we do, but it seems to have been forgotten how much is being and has been done for our fine arts and our commercial prosperity by this very department, including all the multiplied schools of design that have almost exclusively trained the present race of designers. To the influence of the Prince Consort was originally due the starting and the successful accomplishment of the Exhibition of 1851. That the results of this exhibition have taken a permanent form, and are likely to be of lasting value to our manufactures, and hence to our commerce, is mainly due to him also; and we are glad to see, and to join in, such an acknowledgment of this fact as appears at the head of the report, part of which we have just translated.

The length to which this subject has almost necessarily extended renders it desirable to postpone a notice of some other matters, which will be taken up in our next number, but it is right before concluding to direct attention to the great competition open in Paris for a new opera-house, and in which it is proposed in the first instance that only sketches shall be submitted; the authors of a selected number of the best sketches being subsequently invited to elaborate their designs completely, in order that from the limited number of complete designs thus procured, the premiated ones may be selected.

◆

THE PRESERVATION OF STONE.

A discussion being about to take place at the Institute of British Architects* upon the preservation of stone, we are desirous of calling the attention of our readers to a few of the more prominent errors in existence relative to the application of the soluble silicates of soda or potash.

In 1859, the Prince Consort communicated to the Society of Arts two valuable papers, the one by Dr. Johann Nep Fuchs, the second by F. Kuhlmann, Professor of Chemistry at Lille; his Royal Highness further had these communications translated and published, and the scientific world are much indebted to him for these very luminous papers, written more as an analysis of the past labours of the before-mentioned eminent men, and suggestive of a wide field for inventive and persevering genius, than as containing any abstract laws for operating and manipulative details. Antecedent to this period, little was known of these researches, and that little so mystified that, coupled with the slight knowledge, even in our laboratories, of the behaviour of silicates, the subject was involved in comparative obscurity. No sooner, however, had the Society of Arts published the useful *brochure* alluded to, than another claimant to the reputation of Fuchs and Kuhlmann sprang up, and, more for what he intended to do than for what he really had done, claimed even a precedence over those celebrated men; and the scientific world have been on the watch to see how far the theories advanced as superior to those of Kuhlmann and Fuchs were reducible to practice.

The process of silicatisation only was repudiated, as likely to accomplish in an imperfect manner the desired end, from the perfect solubility of the silicate, until deposited in an insoluble form by the carbonic acid of the atmosphere. This is evidently a disadvantage, and one that we were told was to be removed in the new theory by introducing a second solution to decompose the first. If free from a viscid or gelatinous character, a solution might, by parting with its aqueous particles, allow of the ingress of a second solution; but we are certainly astonished at the credence this theory has obtained, and can only account for it by repeating our former remark, that the character of the silicate is but little known, even in our laboratories; for with its peculiar gelatinous character, it defies the ingress of another solution when in that form itself, and, when dry, it is a glassy varnish, that necessarily repels the approach of any liquid application.

If a glass be half filled with silicate of soda, and a solution of the proposed decomposing agent (say chloride of calcium) be poured upon the top of it, a thin film is formed of the silica in combination with the lime; by degrees a thicker stratum is formed, but it is the work of days, and even weeks, to decompose the whole. The intimate contact brought about by stirring, effects a mutual decomposition immediately; hence the fallacy has gained ground that the two materials can be commingled in the pores of the stone. Again, if silicate of soda or potash be decomposed by chloride of calcium, a silicate of lime is undoubtedly formed; but here another great error has arisen by confounding the crystalline silicate of lime, formed by the slow elaborations of nature, with the pulverulent substance formed by the experiment just alluded to. So powdery is this mass, that it will not cohere in its own particles. How then can it be expected to combine other ingredients, or add to the strength of loosely combined materials?

But supposing all these difficulties overcome, and anomalies accounted for, we are led to a far more serious discrepancy between practical observation and these new theoretical conclusions. Most practical authorities are agreed that the sea air is more destructive than that which is free from saline properties, to both stone and brick. This is to be accounted for by the action of the chlorine (common salt being chloride of sodium) upon the lime or alumina forming a most soluble combination, and severe disintegration is the result. Now, in the new theory chloride of sodium is one of the elements formed by the mutual decomposition of the silicates and the chlorides; and instead of being admitted in the small quantities of which the sea breeze would be the conveyancer, it is thus produced in bulk in the stone, tearing away its face in tatters by the alternations of crystallisation and deliquescence. It is said, indeed, in support of this new theory, that the first rain washes away the efflorescence. This is a great error; a simple test will prove that, so far from the salt being washed away by the first rain, the salt retires into the stone, to make its appearance again when atmospheric influences favour its re-efflorescence.

We must not be misunderstood when we assert, first, that the combination cannot take place in the stone; and then that, if it does, it is destructive to it. We mean to say that, under all ordinary circumstances, and with practicable means of appliance, the stone cannot be saturated or charged with two solutions. But under extraordinary circumstances, and with artificial (or not ordinarily practicable) means of appliance, if the deposition of the silicate of lime be effected, the results from its twin element are those of the destructive character before named. The appearance of some samples of indurated stone is very likely to deceive, but the extreme hardness is always a proof of the absence of the new theory, and the presence solely of the silicate, the entrance of the chlorides not having been effected.

It then remains for a system to be propounded by which the deficiency of Messrs. Kuhlmann and Fuchs' system may be supplied. In all efforts in this direction we believe the publication by the Society of Arts of the pamphlet before referred to will prove to be the best basis of research, and will lead to its ultimate accomplishment, for accomplished it assuredly will be. Very much has been done in relation to the preservation of wood, a far more perishable material, and we shall certainly never yield the point until our stone also shall be proportionately increased in durability, and premature decay be unknown.

We do not claim the exclusive right of judging or condemning the various processes before the public, but we are supported in our opinion that not one of them is worth adoption by the negative opinion of Prof. Faraday and Sir Roderick Murchison; for unquestionably, if these gentlemen had faith in any existing process, their valuable opinion, and the premises from which it was deduced, would not be withheld from the public by men, the one object of whose labours is the promotion of scientific knowledge, and the good of their fellow countrymen and the world at large.

We shall be only too glad to assist in the development of any invention or process for the accomplishment of so important an object as the preservation of our national edifices, but such must have tenable premises, with really scientific and truthful deductions therefrom.

◆

ARCHITECTURAL PHOTOGRAPHIC EXHIBITION.

Beyond a doubt the best architectural photographic exhibition that has yet been offered to the public is that now on the walls of the Conduit-street Galleries, and which was opened under very favourable auspices by a *conversazione* on the 15th ult. In passing this general opinion, we do not so much allude to the number of the works exhibited, though this is considerable, as to their variety and novelty, selected as they have been, in the majority of cases, with excellent judgment, and a due appreciation of pictorial effect. Perhaps it would not be easy to mark any great advance in the manipulations and processes of the art itself, as distinguishing the present collection from previous ones, but it is satisfactory to hope that some of the difficulties which have hitherto beset the attempts to take *interior* views are gradually vanishing, though, of course, the diminished influence of that all-important agent, light, and the fact of its transmission through glass, sometimes coloured, and generally not over-transparent, must always more or less affect the brilliancy and distinctness which give a peculiar value to external effects. We are glad to observe, too, that many artists have taken subjects expressly for this exhibition; and "it has been sought," as the committee observe in their report, "by inviting suggestions for the works which shall form the subjects of photographs, and by directing the attention of photographers to these subjects, to advance as much as possible the practical character of the subjects exhibited." One other point in the report we may also advert to, as giving evidence of the diffusive character of the society's operations, it having during the past year lent portions of the collection of photographs to local art exhibitions in Birmingham and Devonport; while negociations are now pending with the same view in other towns, which will tend to promote the interests of the association, and thus confer a reciprocal benefit.

---

* The discussion referred to was to take place on the 28th of January, before which date the above article was in type.

† See *C. E. & A. Journal*, vol. xxii. pp. 215, 264.

We observe from the catalogue (which, by-the-bye, is a model as regards the classification of contents, and its general compilation,) that the present collection amounts to nearly 600 subjects, including those of sculpture and bas-reliefs, which are to be taken by subscribers "only in excess of current subscriptions," and a few photographs culled from the exhibitions of former years, and now again offered, under the same restrictions as the sculpture.

The general collection comprises gleanings from various parts of the United Kingdom and the European continent, with a most interesting series from India, and others from Egypt, Carthage, &c. The largest and most exquisite specimens are the production of Bisson (*freres*), such, for instance, as the three from Notre Dame, which are among the first enumerated. The portals from Rheims, also (10, 11), with the four from Rouen (15, 16, 17, 18), are delightfully perfect reproductions. Indeed, the number of continental cathedral portals which have attracted the efforts of the photographers would form an exhibition of itself; and by the judicious way in which they have been arranged on the walls, abundant opportunity is afforded for examining them either individually or by comparison. In some cases additional value is imparted by some special part, to a larger scale, being superadded to the general view. Among the other contributions of MM. Bisson which demand attention, we may mention the "Tower of St. Jacques de la Boucherie, Paris" (1), the three views from the "Chateau of Blois" (26, 27, 28), and the fantastically designed "Lantern" of the chateau at Chambord, the detail of which is marvellously assimilated to our own Jacobœan work. Some portions at large of "Antique Sculpture in the Palais des Beaux Arts, Paris" (59, 60), show ingenious arrangements of Corinthian capitals. M. Legrey exhibits but five subjects, four of which illustrate the tympana of the portals at Notre Dame, and the groups of sculpture which they respectively contain. We may point to these as, among their class, especially meritorious. The numerous picturesque scraps, as well as charming buildings at Rouen, have not been overlooked; and artists appear to vie with each other in showing them from all possible points of view. The six French specimens, forwarded by Messrs. Cundall and Downes (104—109), are all from Rouen, and comprise the doorway of S. Maclou, and several portions of the Palais de Justice. The photographs taken in Spain by the same artists (110—115) will be found more interesting because their originals are less known; though mostly only of "doorways," they furnish an instructive lesson in the peculiar architecture of their respective periods.

Egyptian architecture reasserts its severe majestic dignity in the fragments from Denderah, Karnac, Philoe, and others, supplied by Mr. F. Frith, whose previous labours in this sphere are well known and appreciated. The series before us is, however, somewhat lacking in point of interest, owing either to the isolation of comparatively unimportant features, or to the small scale in which the general views are usually rendered. This remark does not refer, of course, to the large and very elegant capitals which form the subjects of several sheets. In these we observe the peculiarly sharp yet severe outline of their ornament, which tells so well in the atmosphere for which they were designed.

Carthage! who knows anything whatever of its ruins save through historical tradition? Yet Mr. Moens, with the aid of the wonderful discovery whose results we are contemplating, has contrived to bring before our eyes ancient aqueducts, large cisterns, and a temple, which will not fail to excite the inspection of curiosity. Besides these, Mr. Moens sends some gleanings from Athens, Sparta, Mycenæ, Sevastopol, Inkerman, Palermo, &c. (156—164).

India, too, as we hinted before, is not forgotten; and Dr. Murray has proved a liberal contributor. Among the palaces, mosques, forts, and tombs which here find a place, perhaps the most noted is the far-famed Taj Mehal, at Agra, the peculiarities of which are readily discernible. The "Street View at Multra" (182) is curious, and equally characteristic. On Screens Nos. 3 and 4 are other scenes from India, photographed by Capt. Dawson and Capt. Dixon (453—488). The former sends some interesting groups from Trichinopoly, and the latter, several representations of those curious rock-cut caves peculiar to that country.

From Scotland (and especially Iona) and Ireland there are numerous photographs deserving of notice, but which we need not enumerate, as they will commend themselves at once to the observer; though we may just allude to the varieties of simple early arches pourtrayed in the photographs from the monastery and cathedral at Iona, and the important series, by Mr. Church, jun., from Glasgow Cathedral.

England, as may be expected, contributes by far the largest proportion of illustrations; and the names of Roger Fenton, Bedford, Dolomore and Bullock, Cundall and Downes, and others, are a guarantee for their excellence. In this department there is a great accession of new subjects, interspersed among the old familiar ones; which latter, nevertheless, not unfrequently appear, on this occasion, under slightly different aspects. Our noble cathedrals, especially, prove an inexhaustible field for photographers as well as artists, as the walls of this exhibition testify; and the glimpses of their interiors which occasionally meet the eye, will be welcomed as more or less successful applications of the art. Among the general subjects we are at a loss to particularise, but would name with especial commendation the views of Tewkesbury Abbey (79—84), and Shiffnal Church (85—89), all photographed by Mr. Delamotte; also the Saltash Bridge (91), by Messrs. Cundall and Downes; some interesting views from the Isle of Wight, by Mr. Gordon (116—122); numerous views at Furness and Southwell (202—223), by Mr. Fenton; Messrs. Dolomore and Bullock's "Ely Cathedral" (296—308); Capt. Austin's "Canterbury Cathedral" (351—366), and Mr. Bedford's "Wells" and "Bristol" Cathedrals (251—260) (228—233); also his beautiful specimens of carving and iron scroll-work, from St. Paul's Cathedral (237—250). These are especially valuable, as being among the best specimens of their style—the work of Grinling Gibbons, and others,—and as having never before been taken; this being indeed rendered practicable now only in consequence of the peculiar condition of the building at present.

The exhibition will be open daily until the 14th of March, and on Tuesday evenings from seven till ten, on which evenings lectures bearing upon the subject are in course of delivery. That on the 22nd of last month was given by Mr. Joseph Bonomi, on "The Egyptian Photographs;" and that on the 29th by Mr. I'Anson, on "The Photographs of French Renaissance Architecture;" while the remaining lectures are as follows:—Feb. 5, by Mr. Ashpitel; Feb. 12, Mr. Pullan, on "The Photographs of French Gothic Architecture of the 13th Century;" Feb. 19, Mr. Fergusson, on "The Collection of Indian Photographs;" Feb. 26, Mr. E. B. Lamb, on "Architectural Progression;" March 5, Mr. Seddon, on "The Grotesque in Art;" and March 12, Mr. Burges, on "The Collection of Photographs generally."

◆

ON THE LARGE BLASTS AT HOLYHEAD.*

By George Robertson.

Blasting operations may be divided into three distinct classes, according to the effect intended, and the intensity of the charge of gunpowder—1st, Where rock has to be separated by weak charges, with as little injury and fracture as possible, principally for building purposes; 2nd, Blasting for engineering works, as breakwaters, &c., where quantity and regularity of supply are of more importance than size and regularity of fracture; 3rd, Military blasting, where total destruction is aimed at, and where an excess of powder is little or no objection.

In the first class, the charges of gunpowder can hardly be too weak, so long as the stone be separated, and small charges are preferable to a large quantity at once—the object being to procure stones fit for masonry, with as few cracks and shakes as possible. In the third class, the charge can hardly be too strong, the chief difficulties being those of carrying on operations under an enemy's fire, with the speed and secresy consequent thereon. It is to the second class, that of "engineering blasting," that the following observations are directed.

After describing the system pursued in working the quarries by large blasts, the calculations will be given for regulating the charges, and lastly the cost of "getting and filling" stone on the large scale. In an engineering point of view the subject is one of considerable importance.

---

* Read at the Royal Scottish Society of Arts.

The period more immediately referred to in the paper is from 1850 to 1853, when the large blasts were first introduced at Holyhead—the late Mr. Rendel being at that time engineer-in-chief. After his death in 1856, Mr. Hawkshaw was appointed engineer. Mr. G. C. Dobson has been resident engineer since the commencement of the works.

Since 1853 the large blasts have gone on regularly as matters of every-day occurrence, exciting little curiosity and giving little trouble. At first however they were the subjects of much anxiety and experiment, both in a practical and an economic point of view. The best method of working the quarry on the large scale, and the calculations for the charges of powder, were not determined upon without considerable expense, danger, and even loss of life.

The rock of which the breakwater is composed is a very hard quartzose and micaceous schist, slightly stratified; in some places bearing marks of former flexibility, the strata being twisted and contorted in a curious manner. It is intersected by vertical joints, running in a north-east and south-west direction, presenting faces fronting the north-west and south-east. As will be seen hereafter, these joints were taken advantage of in fixing the position of mines, and in calculating the expected produce of a charge.*

To supply the great demand for the stone required for a bank 350 feet broad at the base in deep water, within a limited contract time, evidently necessitated the most vigorous efforts; and accordingly an extensive system of small shots was at first arranged, giving employment to above 1000 men. The holes for these shots were of all sizes and depths, according to the judgment of the foremen of the quarries. For convenience sake the quarries were divided into portions, consecutively numbered, or were called by the names of the different foremen, as "Jones' quarry," "Fisher's quarry," &c. The boundaries were however ideal, as the face of the rock altered with each great blast.

To avoid the danger and delay of firing shots at all times of the day, whenever the holes were ready and charged a general grand firing took place, twice, or if necessary thrice a day. When a large bell sounded the quarries were emptied of men, horses, cranes, and all plant easily destroyed. The fuses were simultaneously lighted, on a red barrel being hoisted to the top of a tall mast. Each man as he lighted his fuse cried "fire," and made the best of his way by scrambling up ropes to a place of security, or to one of the bomb-proof huts erected for the purpose. As the face of the rock was often above 100 feet high, this was a service of no small danger, and accidents frequently happened.

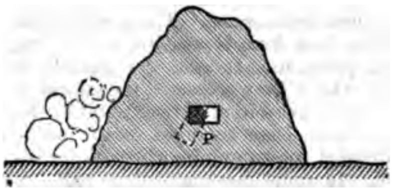
The average work done over the whole quarries, in drilling holes for the small shots, was 14 inches per hour, by three men using 1½-inch drills. The charges were regulated chiefly by the "rule of thumb," or at most by the ordinary miner's rule of one-third of the hole, independent of the diameter—a rough rule, certainly, but better than so many "capfulls," the cap being a very common measure. Indeed, where 100 or more shots went off twice a day, it was impossible to be very particular. It is unneccessary to go into further details regarding these small shots. The system will be found fully described in Sir John Burgoyne's treatise on "Blasting." Wherever it was possible, powder was poured into cracks in the rock, and the rent tamped as well as its form would admit. There was often a considerable waste of powder, but the shots were very effectual in bringing down large masses of rock. This system is pursued to great advantage at North Queensferry, in blasting columns of whinstone.

About the year 1850, the contractors for Holyhead breakwater, Messrs. Joseph and Charles Rigby, commenced a system of large mines, rightly conceiving that a quantity of powder fired at once would in the end prove cheaper, and afford a greater and steadier supply of stone, than a number of small shots. Since then the supply has been over 3000 tons per diem—often 4000, weather permitting; 5000 tons a day was seldom if ever reached, not from want of stone, but from the difficulty of depositing such a quantity during working hours, even with five lines of railway on the staging. To do this requires 125 waggons for each line of rails, or a total of 625, to be loaded, run down from the quarries, tipped into the sea, and drawn up again to the quarries, every day. The waggons held about eight tons each, were made of wrought-iron, and furnished with tipping gear, which released the scoop when the trigger struck a catch on the rail. The scoop was counterbalanced to return again to its original position when the stone was discharged.

The first large shots tried were shafts sunk from the top of the quarry. They were about 6 feet by 4 feet, of different depths of course, according to the height of the rock; and were charged with reference to the lines of least resistance, or the shortest distance of the shaft from the face of the quarry.

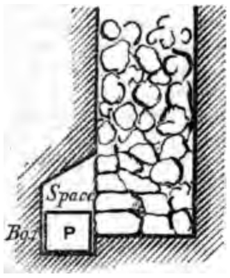
As the danger of blowing out the tamping was greater than in small shots, from the increased diameter of the hole, care had to be taken that the depth of shaft was sufficient to allow the weight of the tamping to resist the powder. The rule was that the shaft should have one-third less grip (or distance from the face) than depth as a maximum; and the depth was oftener twice the line of least resistance, or even more. This is however not so great a proportion as in small shots; but in the shafts the chamber at the bottom for the powder was bent to one side, so that the tamping was never in the direct upward line of fire (see Fig. 1).

Fig. 1.



Charge, 600 lb.; produce, 3000 tons.

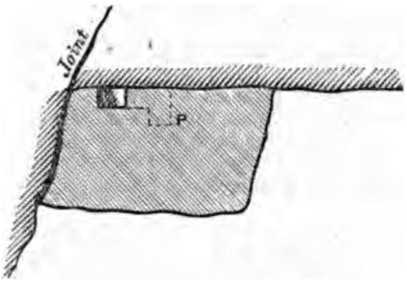
Fig. 2.



Enlarged section of chamber.

The most favourable position for a shaft is in the centre of a projecting column of rock, where (as in Fig. 1) the lines of least resistance are nearly equal on all sides. This mine (one of the first) was fired on Nov. 13, 1850, and was 42 feet deep, with half that, or 21 feet of least resistance on all sides. It was charged with 600 lb. of powder, and yielded 3000 tons of stone; one of the highest comparative results obtained, being 5 tons of stone for each pound of powder. An enlarged section of the chamber is given in Fig. 2. Had it not been for the remains of a previous blast on one side the result would have been even higher.

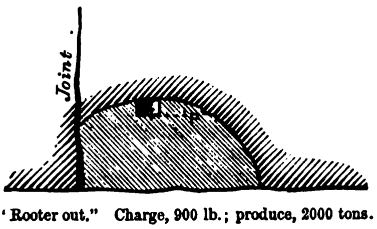
Fig. 3.



Charge, 1800 lb.; produce, 3500 tons.

It is seldom that a shaft can be placed in so favourable a position as this, and Fig. 3 shows the most common, and the next best position—viz. that of blowing off a corner. I recorded this mine chiefly because it was an example of the effect of inferior powder. The depth of the shaft was 44 feet; the line of least resistance 30 feet; and the charge 1800 lb. of powder. This only produced 3500 tons, or less than 2 tons to the pound of powder, in place of about 5000 tons, which good powder would have given, and generally did give in so favourable a position.

Fig. 4.

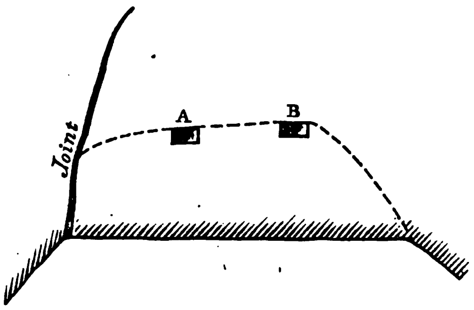


"Rooter out." Charge, 900 lb.; produce, 2000 tons.

Fig. 4 shows a very common but very unfavourable position for a shaft, where a straight face of rock has to be broken up, and where the powder has to tear its way out under disadvantages. The miners call this a "rooter out," and it was almost always placed so as to have a joint on one side which determined the line of fracture. The example shown (Fig. 4) had a depth of 44 feet, with a line of least resistance of 21 feet. The charge was 900 lb., and the produce 2000 tons, or 2¼ tons per pound of powder.

The very worst position for a shaft is at a re-entering angle, or nearly so, as in Fig. 5, where the rock binds it in on all sides. The ratio of powder for a mine like this had to be greatly increased according to circumstances.

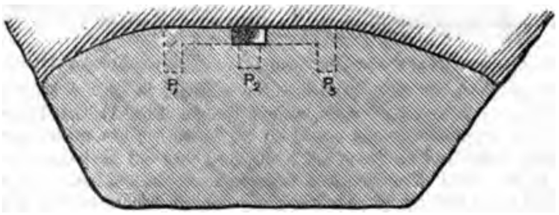
Fig. 5.



A blew the tamping out; B did not explode.

The powder was not always in one spot, but was often divided into two or three charges, placed at the end of galleries driven from the foot of the shaft, in directions determined by the neighbouring joints or cracks. In Fig. 6 for example, the whole charge, 8000 lb., was divided into P_1 of 2800 lb., and P_2 and P_3, each of 2600 lb. The depth of the shaft was 67 feet, and the line of least resistance 42 feet. This mine produced 23,000 tons of stone, or nearly 3 tons of stone to the pound of powder.

Fig. 6.



Charge, 8000 lb.; produce, 23,000 tons.

It is to be noticed that in most cases it is better to spread the powder along the face of the rock in two or more charges, than to have the whole in one spot with a greater line of least resistance. In the latter case the rock is thrown forward in larger masses, and is neither so well broken up, nor does the heap present so many points of contact for the waggons to load at. It was found from experience that 30 feet was about the economic limit for the line of least resistance, and the powder was seldom at a greater distance than that from the face of the quarry.

Occasionally two separate mines with their respective shafts were fired simultaneously side by side. There was some little danger of the two shots (which were fired by a galvanic battery) not going off together. This actually occurred on the 24th Feb. 1851, when two contiguous shafts were to have been fired at once; but owing to the accidental fracture of one of the battery wires by a previous small shot, B (Fig. 5) did not explode. The mass of rock in front was too great to be moved by A without the assistance of B; and the whole tamping in A was blown out. An immense shower of stones was hurled into the air to a great height, and fell amongst the spectators, who lined the side of the mountain. Strange to say, the only person seriously hurt was the gentleman who had planned and directed the mine, Capt. Hutchinson, of the Royal Engineers. He was struck down with a broken thigh, and died the same night. His wife and several ladies, who were talking to me at the time, had their clothes torn by great stones falling on them, but escaped with some trifling injuries. Capt. Hutchinson had had great experience in blasting, having been engaged both at Gibraltar and at Dover, when the Round Down Cliff was blasted in 1845.

◆

THE PRESERVATION OF STONE AND FRESCO-PAINTING.

The attention which this subject has lately received, and the full discussion which from its importance it merits, will give an interest to the article which we reproduce from a recent number of the *Encyclopédie*. It may not be out of place to remind our readers that in none of the localities enumerated as possessing successful examples of the use of M. Dalemagne's invention is the climate at all so injurious in its effects upon building stone as that of London, and other large towns and cities in Great Britain where large quantities of coal smoke mix with the atmosphere and impregnate the rain-water with active chemical agents.

> "*On the Silicating of Stone, applied to the Preservation and Restoration of Works of Antiquity.*
>
> It is long since we originally indicated to our brother architects (*confreres*) the process, now universally known, by means of which M. Dalemagne has succeeded in arresting the decomposition of calcareous stones, by means of, so to speak, infusing fresh blood into them.
>
> We crave permission to quote some lines of an article on this subject that appeared in the number of the *Encyclopédie* for November 1853. We then said, 'The experiments (of silicating) made in the courtyard of the Louvre, and which we have carefully examined, have appeared to us conclusive. At the base of Lescot's façade, parallel to the Seine, one course in a very bad state of preservation, which has been only partially saturated, enables one at a glance to form an opinion how far the process is efficacious. While the portion not operated upon remains pulverulent and friable, that silicated has acquired great powers of resistance, and its decomposition has been arrested.'
>
> After a lapse of seven years we have again seen this piece of stone, and have with satisfaction noted the fact, that Time the great destroyer has not been able to penetrate the protecting surface formed by the silicate. It is with pleasure that we now find ourselves in a position again to publish this interesting result.
>
> Silicating is however too well known now for it to be other than superfluous to recommend its employment to architects; and the works carried out by M. Dalemagne on the cathedrals of Paris, Amiens, and Chartres, at the Louvre, the Ecole des Beaux Arts, the palaces of the Luxembourg, Versailles, Fontainebleau, &c.—these works, we repeat, are too decisive for a single word to be needed in addition.
>
> We have been induced to return to this subject in consequence of a new application, also very interesting, of M. Dalemagne's process, which consists in the use of a siliceous cement, not only intended to preserve the stone, but in certain cases to replace it. This cement, composed of a mixture of pure silica with silicate of potash, has been lately successfully tried in the church of St. Denis, under the direction of M. Viollet-Leduc; and has been made use of by M. Villeminot, a sculptor of much merit, in the restoration of the statue of Charles Martel, in which instance it has acted well, both in the restoration of portions missing, and in cementing together others. A few days, even a few hours, sufficed to give it a hardness exceeding that of stone; and the cohesion of the cemented portions appeared to us proof against any attack.
>
> Another trial of this cement has been recently made by M. Baltard, for the restoration of the sculptures of the Fontaine des Innocents. We have not so closely examined the results of this operation, but we are assured that they are not less satisfactory than at St. Denis.
>
> We congratulate M. Dalemagne on having been able to place a material at the disposal of the architect which is none the less valuable for us that its office is an humble one. We wish to this cement the same fortune as has fallen to the lot of its elder brother the silicate; and we form this wish all the more heartily, because a new success would be the due recompense of the persevering efforts and conscientious exertions of the inventor."

In the December number of the same journal a letter from M. Dalemagne himself is inserted, disclaiming the credit of being the inventor of the silicating process. but giving the credit of it to M. Fuchs, of Munich, whose name has also been brought forward in this country when the subject has been broached. It appears however, that notwithstanding the modesty of this disclaimer, M. Dalemagno really did first introduce that application of the cementitious qualities of silicate which forms the cement alluded to. He observes, referring to Fuchs, that "he had written that silicate would form an excellent mineral glue, and I have found that by combining with it silica reduced to an impalpable powder, in proportions varied to suit the nature and composition of different stones, together with the powder of the stones themselves, a cement is obtainable the strength of which will stand any tests."

The letter refers to a further invention of Fuchs, called Stereochromy, or monumental painting in silicate, probably a variety of fresco. This plan, it is said, has been practised by Kaulbach and Eichter, at the Berlin museum, and a description of the mode of procedure is in course of publication. It seems to us, that if this process can be depended upon to afford a good and permanent vehicle for fresco-painting, it will be well worth attention in this country; for our attempts to introduce this style, unquestionably the noblest manner of painting, and one almost inseparable from the highest class of pictorial art, have been rendered almost nugatory by the difficulty experienced in getting a plaster that would entirely withstand the action of time and moisture.

ON THE ARRANGEMENT OF CHURCHES.*

By A. W. Blomfield, M.A.

My object in the paper I am about to read will be to take a practical common-sense view of this deeply interesting question, both with reference to the ritual of the Church of England as it now exists, as also to the peculiar exigencies and requirements of our own times, and the means at our command for meeting them in the most natural and straightforward, and therefore in the best manner. In following out this plan, time would fail me to enter into any detailed description of mediæval or earlier church arrangements, or even to allude to them, except so far as I find it necessary to do so in illustration or support of my views. If my remarks therefore fail to take the interesting line of archæological research which might have been expected, it is not that I at all underrate the high importance of this line of study in all its branches, but that I take it for granted every one who aspires to the honour of being a church architect habitually pays especial attention to it; and we are therefore at liberty this evening to devote ourselves to the present and future rather than to the past. Thus also I have avoided a very interesting branch of the subject which was open to me—viz. the symbolism of church arrangements; not because I slight the study of it, but because I think it involves questions scarcely practical enough for our evening's discussion, and because I think a system of mystic symbolism (beyond that which explains itself at once by familiar use, or as distinctly scriptural) when it is merely based on human fancy and ingenuity, is in this age as much a toy and dead letter as the science of heraldry is amongst the sciences.

What I propose to consider then is—First, the influence which our ritual as it at present exists ought to have on the architectural features and character of our churches; in what manner it ought, in other words, to make itself felt in the building; and whether we are in the habit of paying sufficient attention to this point. Secondly, the customs, wants, and requirements of modern congregations as compared with those in the former ages of the church. Whether those customs, wants, and requirements are to be ignored and slighted, or whether they ought to be met; and if so, whether we ought boldly to acknowledge the means we employ, and make the most of them, or to conceal them, and as far as we can apparently dispense with them altogether, because they do not fall in with preconceived notions as to what is "ecclesiastical." It will be observed that I place first the question of the influence our ritual ought to exercise on church architecture, because, if that can be determined we may, I suppose, safely say that what has nothing to do with our ritual is not absolutely necessary to give due expression to a church, or, in other words, is not intrinsically ecclesiastical.

The first reformed English liturgy was produced in 1549, and was followed in 1552 by a second, which is nearly identical with our present Book of Common Prayer. Since that time it has undergone several authorised examinations, and some few changes of importance have been made in consequence, but in all essential points it continues the same. Thus it will be seen that precisely at the time of the great change in our church services the knowledge and practice of the true principles of architecture had passed through their last phase, and died out, so that the only object of the Reformers naturally was to obliterate as far as possible all traces of the Romish rites and ceremonies in their churches, without any thought of what might be preserved or adapted as expressive of the new liturgy. Since that time church building has gone through many curious changes, and remained for a long time at a very low ebb; and although no one can doubt that we are in the right road now, how few churches have as yet been built that can at all bear comparison in point of interest and a certain instinctive sense of complete fitness, even with the plainest churches of the best mediæval periods! Let us consider what is the cause of this.

When we hear a new church discussed, the points usually touched upon are the accommodation, the cost, and the quality of the design. We hear, perhaps, that sittings are provided for 800 or 1000 persons, and that it cost so much,—very cheap, or very expensive, as the case may be. Then we hear the particular style adopted, the height and treatment of the roof, the richness of the decoration, and the originality, if there be any, of some part of the design, with numerous other details; but we seldom —I think I may almost say, never—hear a church commended because the building itself, independently of its furniture, gives expression to every part and detail of our services. I do not mean broadly to assert that none of our modern churches do give such expression, though as a rule they certainly do not; but I mean to say, that when such an exceptional church is met with, people do not appear really to know why they like it: they think it original and clever, but they cannot exactly say why it interests and satisfies them more than larger and costlier buildings, or why, without any copyism, the architect seems to have succeeded in catching the true spirit of Mediæval architecture. Now I think, that unless we discover the element of his success, and recognise it as a principle not lightly to be infringed, we shall not make much progress in church building beyond the point to which the revival has already carried us. Do not suppose that I am presumptuous enough to speak disparagingly of what has been done and is now doing, nor to imagine that I can tell you anything new and startling on the subject of church arrangements; but I cannot help thinking that there is a good deal of misapprehension and false feeling afloat on this question, and the more we can work together and mutually assist each other to recognise true principles, and sift them from unfounded prejudices, the better prospect have we of that onward progress without which art must decline and die.

I suppose we have all felt, in comparing old and new churches, that there is often a deep sense of interest and continued satisfaction in exploring an old church, although it may be very plain and simple, which is totally wanting when we visit a neighbouring modern church, apparently its superior in all the usual architectural features. This is generally attributed to the charm of antiquity and the sentiment of association; and these feelings no doubt have their due weight. But there is something beyond this, which I believe to be the existence in the old building of a principle, apparently instinctive in the mediæval architect, which is too often, I cannot but think, overlooked by us. The principle I allude to may sound absurdly trite and hackneyed, but it cannot be too often repeated until it is better attended to: it is simply, *that a building should exactly express its purpose*, or in other words, in the case of a church, that the bare walls or actual skeleton, before a bit of furniture is introduced into it, should bear the distinct impress of every part of the ritual existing at the time of its erection, and should give expression to all ceremonies and forms of worship about to be celebrated in it. Thus, it may well be regretted in a purely architectural point of view that we are forbidden to erect stone altars: they were removed in 1550 to make room for communion tables, and though we may deplore we can scarcely wonder at the measure. Mosheim in his 'Ecclesiastical History,' remarks, "Posterity may regret this change as needless in itself, and an injudicious sacrifice of a venerable decoration; but contemporaries alone can adequately judge of such questions, and they (the Reformers) had undoubtedly a degree of difficulty in weaning the people from inveterate superstitions, which rendered all incentives to them obnoxious." But though our altars may not be of stone, we still may, and no doubt ought always, to mark by some constructive feature the exact position of the holy table,—not necessarily elaborately and expensively where funds will not allow it, but at any rate distinctly and thoughtfully; and let us always remember that, on no higher than artistic grounds, a little extra cost here at the expense of the body of the church will have far more value than the same amount expended in a sprinkling of meagre and uniform decoration over the whole building. I do not wish in a paper of this kind to say too much upon the higher grounds for making this the point of attraction in the church, nor to insist at too great length on the credence table, piscina, and sedilia as architectural features, seeing that these are, after all, only adjuncts depending on particular forms and methods of celebration, the propriety of which this is neither the time nor place to discuss. But the principle of always expressing the position of the altar by a solid reredos depends simply on a question of fact,—"Is the most sacred and solemn portion of our ritual celebrated there, or not?" If it is, the building itself should bespeak the fact.

To proceed next to the Font. Although the orthodox, traditional, and symbolical position of the font near to the western entrance is now very generally adhered to, I have heard a great many different opinions amongst the clergy as to its convenience. Amongst others Mr. Pettit remarks, "Where the font is suffered to retain its original position it is generally found near the western entrance, and this without doubt is the most appropriate spot for a ceremony denoting admission into the church;

---

* Paper read before the Architectural Association.

yet there may often exist sufficient reasons for placing it elsewhere. And it is of far more importance that we should regard, both in position and design and the actual size of the font, the great solemnity of the rite which is administered in it, than that we restrict its locality to any particular part of the building." Wherever it is placed, its position should at any rate be well defined and expressed by some modification or exceptional feature in the architecture, so that there may be a perpetual and ineffaceable protest against any future removal by a reforming churchwarden or a new incumbent.

I know an instance, by the way, of a font in a large modern church, which has been moved from east to west and back again, three times in as many years; and in this case, as far as the building goes, one place is as appropriate as the other. It would of course be inconsistent with the custom which prevails of administering baptism during divine service, to place the font in a distant baptistery where it could not be seen by the congregation; but if a little thought be bestowed on it, we shall generally find that some distinctive feature may be introduced which will add interest and beauty to the church and fulfil the purpose I speak of, without cutting off the congregation from participation in the service. Mr. Pettit, a little further on in the passage I quoted just now, supports the principle of making the font as far as possible a part of the building, and not an appendage. He uses this last term in speaking of the font, and then immediately adds—"An appendage indeed I should not call it, as in old times it was considered the very heart and nucleus of the church, erected often long before the walls and roof which were to cover it. The well-known font of St. Martin's at Canterbury, is evidently much older than any part of the present building, and it is not improbable that it even preceded former ones. In Norbury Church the font is decidedly Early English, none of the building being earlier than late Decorated—most of it of the latest Perpendicular.

There are of course numerous examples in churches built of late years in which the font is given its proper importance, and has a well-defined and yet prominent and open position given to it. An arrangement of the kind has been admirably managed in a small church in Suffolk, lately built by Mr. Scott, where a round tower (after the fashion of the peculiar round towers of that county) is placed at the west end. It is vaulted with stone internally, and forms an appropriate baptistery. But having noticed the principle, I will not take up time by multiplying examples.

Let us pass next to the consideration of the Reading-desk and Pulpit. Now, although these two play, if not the most important, certainly the largest part in our services, it is not often that we find one or the other treated as part of the building, or influencing its constructive details in any way. They are usually pieces of furniture which give no more impress of character to the building than the seats of the congregation. The exact position of each, and even the design, are generally not settled until the church is nearly completed; perhaps indeed it is fortunate sometimes in the case of the pulpit, as instances might be found where, through inattention to acoustic requirements in the first instance, a change in its position is absolutely necessary. But supposing the pulpit is of stone and the reading-desk on a stone plinth, this is not all that is required to meet the principle we started with, unless they form part of the building. You may have stone furniture as independent of it as wooden furniture; and with regard to the reading-desks, architects unfortunately find a great difference of opinion among the clergy: one wants a large desk looking north and west; another wishes the whole desk to face the west; and a third wishes perhaps to read prayers from a small desk in the chancel seats, and the lessons from a movable lectern. Without venturing to express an opinion as to what is absolutely the right form of reading-desk in a ritualistic point of view, I feel a strong conviction that, architecturally speaking, wherever prayers are habitually read by the minister, the building should give some indication of the fact. We have before us the well-known examples of the arrangement of the early Christian basilica, where we find this principle carried out in every point as completely as could be done in adapting a building originally designed for secular purposes to the requirements of public worship: such parts of the building as could be still used in Christian worship were adapted, and what was wanting was added architecturally, and incorporated in the building as far as possible. Thus, the bishop and presbyters, as you know, took the places of the prætor and his assessors, the Roman altar became the Christian holy table, and a quire was thrown out into the nave, inclosed on three sides by low walls. The ambos, from which the gospel and epistle were read, were actually built into these inclosing walls, and thus made part of the church. The church of San Clemente, at Rome, as you all know, shows in the most perfect manner the arrangement of the early basilica. Although rebuilt in 790, it was exactly on the original plan, and it is owing to the fact of all the ritualistic arrangements being absolutely solid and architectural, and not merely movable furniture, that we are able at this time to understand fully the allusions and descriptions of early writers Those who have not seen the church itself to judge of the eloquent manner in which the building speaks its purposes, will find it illustrated and described in Gally Knight, and in Fergusson's 'Handbook.'

Now, although the ambos do not exactly answer to our reading-desk, yet their uses were sufficiently similar to justify the analogy, and I think we may well take a hint from them. There is a good reason for the lectern to be movable in the fact that a layman sometimes reads the lessons, as is the custom in college-chapels, and not unfrequently in village churches, but I think we ought certainly to make the prayer-desk an architectural feature.

Next as to the pulpit. At least two sermons are preached from it every Sunday in most cases, so that I suppose the preaching of sermons may be considered a fixed and essential part of our services, and if so it ought undoubtedly to find expression in the architecture of the church. Now here, where we are at perfect liberty to look for assistance to the best times of art (seeing that the conditions for addressing a congregation must be much the same in all ages and for all creeds)—here, where we should find plenty of assistance if we did look for it, we seem to neglect it in an unaccountable manner. I will just read a short extract from Viollet-Leduc's 'Dictionary' on this point, which exactly illustrates my remarks. In the article on 'Pulpits' he says—"In France none of our ancient churches have, as far as we know, preserved any pulpits of an earlier date than the fifteenth century. It was customary from the commencement of the twelfth century in our northern churches to arrange a rood-loft at the entrance of the choir, from the top of which the epistle and gospel were read, and exhortations addressed to the faithful when occasion served. In every case these sermons, before the institution of preaching friars, only took place occasionally. It is probable that in particular cases sermons were preached from a movable pulpit, arranged in some part of the church for that occasion. The pulpit was then only a little wooden stage, closed on three sides, and covered in front with a hanging. But in the thirteenth century, when the preaching orders had been established, to combat heresy and to explain to the people the truths of Christianity, preaching became a necessity which the architectural arrangements of religious edifices were compelled to obey. Exactly to fulfil these conditions the Dominicans and the Jacobins, amongst others, built churches with two naves, one being reserved for the monks and divine service, and the other for preaching; then the pulpits became fixed, and entered into the construction. They formed, as it were, a balcony projecting into the interior of the church, carried on corbelling, accompanied by a niche taken out of the wall, and generally lit by little windows. Access was gained by a little staircase contrived in the thickness of the wall." Thus we see the thirteenth-century architect at once felt instinctively, that when a sermon became a thing of fixed and regular recurrence instead of an occasional address, he must express the fact in his building. It was no longer sufficient to provide a little movable wooden stage closed on three sides, but he must contrive a balcony, or some architectural feature that should distinctly proclaim its original use as long as the building should stand. There is an instance of such a pulpit in the south of the nave of the great church of the Jacobin convent at Toulouse. It has long been disused, the balcony and corbelling shaved off, and the niche blocked up, but still there are evident remains, and you must pull down the building before you can obliterate the traces of what it has once been. As I said just now, a particular form of pulpit can have no more to do with creed or doctrine than a particular kind of brick or stone in a building (although I have heard a stone pulpit objected to on principle), and if this method of treating a pulpit was right in the thirteenth century, it is right now. We ought to feel as instinctively as the architect of that day that "a wooden stage closed on three sides," in fact any sort of pulpit not entering into the construction of the church, does not thoroughly satisfy a principle we all acknowledge in the abstract.

The examples of ancient pulpits treated in this thoroughly common-sense manner are very numerous, but we must not confine our search after the earliest and best examples to the interior of churches; we shall find some of the best in the refectories of monasteries, used for reading to the monks during their meals. A very fine example of this kind of pulpit exists in a building (formerly the refectory) attached to the cloisters at Chester, and now used as a school. It is well worthy of careful study, and gives a peculiar character and interest to the building. The woodcut in Viollet-Leduc of the beautiful pulpit in the refectory of St. Martin des Champs is, I presume, familiar to all. We find a great variety of later examples, both in the interiors of churches and exteriorly in the cloisters and elsewhere, such as the well-known examples at Beaulieu, Magdalen College, Oxford, and St. Lo, in Normandy. There is one peculiarity about nearly all ancient pulpits which, although belonging more strictly to the second part of the subject, I will allude to now as forming part of their construction,—it is that they nearly invariably have what the French call an *abat-voix*, or voice-reflector (to avoid the obnoxious term of "sounding-board"). Where part of the pulpit was formed by a niche or recess, the roof of the recess of course acted as one; but if attached to a wall or pier, some covering was almost always added. "For pulpits," says Viollet-Leduc, "erected in the open air] or in churches, the necessity was soon felt of suspending a ceiling over the preacher, to prevent the voice from losing itself in space." This is actually now done in the large churches in Italy, with exceedingly picturesque effect, by suspending a large cloth or awning by the four corners over the pulpit. I only mention these facts because there seems to be an unfounded prejudice now against sounding-boards altogether. This is probably owing to the monstrous erections of the last century, which seem by some suspension of the laws of nature to be balancing themselves on one corner, and to be ready at a moment's notice to shut down on the preacher like the lid of a trap. Although apparently of enormous weight, they are generally in fact made of thin wood, and comparatively light, and are altogether shams and abominations; but because they are bad in design, I see no reason why the use of sounding-boards should be condemned altogether. Those of you who heard our president's admirable paper on "Acoustics,"* lately read, will have heard that they have a decidedly beneficial effect in many instances; and I think that, though in most cases it may be unnecessary, where there is any reason to suppose it may serve a useful purpose it would be much better for the architect to incorporate it with his design, and put it up at once with the pulpit, than to run the risk of his work being disfigured hereafter by its addition. In a church with which I am well acquainted, a fine building only lately finished, a sounding-board has been added to the pulpit within the last few months with exceedingly bad effect, cutting as it does into a beautifully carved capital; but the acoustic improvement is so great that we have to overlook its ugliness. I do not know whether the architect of the church was called upon to mar his own design in this instance, but I think it is a case where a sounding-board originally designed by him as part of the pulpit might have been made not an unpleasing feature.

There is still another part of our services which requires notice, and that is the musical portion. The only point about it which I wish to enforce in this division of the subject is this: as an organ is now an almost invariable appendage to a church, and is generally considered necessary to the proper and decent celebration of our service, it should impart a distinctive character to that part of the building which is destined to receive it. I am aware that this is frequently attended to in modern churches, and always I think with a satisfactory effect; I could name instances of churches where such an arrangement has always appeared to me to give the chief interest and charm to the building. In small village churches where an harmonium takes the place of an organ, a recess in the thickness of the wall may be contrived with very good effect, at a small cost, and with unmistakable fitness of purpose.

I have thus briefly and imperfectly noticed some of the points to which we should all give especial attention in order to make our churches what they ought to be—the architectural expression of the ritual of the Church of England. Let us now take a very cursory view of the other branch of the subject, namely, the customs, wants, and requirements of modern congregations, and the effect they ought to have on the architecture of our churches.

To begin with, I think that (arguing from the analogy of former ages) we may lay down the principle that respect for precedent and sentiments of association should not prevent us from discarding any peculiarity of construction or arrangement that is found distinctly inconvenient or unsuitable, and which does not express any part of our ritual. As a simple illustration of this principle, we find that the questionable associations which must still have clung to the heathen basilicas, did not prevent the early Christian congregations from transferring their religious services to them from the baptisteries, which are now believed to have been the original ritual churches. This, of course, could only have been done because the hall of the basilica, with its side aisles, was found to be much more convenient for the decent celebration of their services than the circular and octagonal baptisteries. In the same way, I think that in any point where convenience is at stake we ought not to be too much confined by the precedent of Mediæval architecture. Neither our ritual nor our congregations are the same as those for which our ancient churches were built, and it is scarcely to be expected that if they were exactly suited to one that they would be equally so to the other. We have seen that at the Reformation, Gothic architecture had arrived at its last stage. King's College Chapel, its last great effort, commenced a century before, had been finished about twenty years; and there can be little doubt that had it been possible for a new and true architecture to have sprung up with the Reformation from the ashes of the old, we should have had churches as beautiful but as different from the Mediæval buildings, as they in their turn were from the early Christian basilicas.

Beyond the absolutely essential division of nave and chancel, I do not wish to occupy your time by saying much about convenience of plan. This is a question which must depend so much on peculiarities of site and the number of the congregation, as well as other points, that it would form a long paper in itself. Those eccentric varieties in the form of theatres and lecture-halls I need only allude to, as I hope we are all agreed that turning a church into a great auditorium is not only subversive of all proper ritual expression in arrangement, but renders it almost impossible to conduct the service in a decent and reverent manner.

At this point however it will be as well to take some notice of the vexatious question of galleries. We all know the numberless objections to them, and I suppose no one would employ them by choice, but where they become actually a necessity—which is often the case—they should certainly be located as part of the construction, and their presence should be expressed externally. Great care should of course be taken as to their height and the steppings of the seats, so that they may neither overpower the church by being too high, nor oppress the occupants of the aisles by being too low. A flat ceiling under the galleries will be found to be much better for acoustic purposes, and more satisfactory to the eye than an inclined one. There is one position however for a gallery which is, in some churches, almost unobjectionable, from its answering two good purposes—one, that of breaking up and dissipating the sounds from the east end, and preventing echo; the other, that of clothing the conspicuous bareness of the west wall, which in many churches is far from agreeable.

To return from this digression: let us start with the acknowledged necessity of a nave for the congregation, and a chancel (not too deep) for the clergy and choir; and let us take a modern congregation of, say 1000 persons, and consider the wants and requirements we have to meet. The first thing to be noticed is, that according to received notions the seats must be fixed; and if we may judge from the serious inconveniences which attend the use of chairs where they have been tried, they are not likely to come into general use, except as a temporary expedient. The next requirement is, that all the congregation should have an uninterruped view and hearing of the officiating minister. It may not seem at first evident that an uninterrupted view is necessary, but in point of fact nothing is so difficult or irksome as to keep up one's attention to a speaker who is unseen. This applies of course chiefly to preaching.

The next requirement, whether right or wrong, is that no one should feel too cold or too hot, and that there should be no draughts in the church. It may seem to many beneath the dignity of this subject to notice so trivial a detail, but as a matter of fact it will be found to be considered a most important thing, and it is not for us to decide whether it is right or wrong. If the the age demands warming and ventilation, we must give it them.

---

* See Journal *ante*, page 2.

Now let us compare with this mediæval and earlier congregations. The warming of churches may be considered, I suppose, in the first place, quite a modern luxury; next, as to seats, in the basilicas there were certainly no fixed seats except for the clergy—the congregation, whether standing or kneeling, arranged themselves round three sides of the choir. No one would then place himself by choice immediately behind a column, a defect unfortunately unavoidable in a modern aisled church with fixed seats. In our mediæval churches, on the other hand, distinct hearing of the services was a matter of no particular moment, as the loss of a syllable or so of an unknown tongue could not interfere with the devotions of the faithful, and sermons did not form a regular part of the services, as they do with us. I am far from wishing in large churches to abandon aisles, and substitute a large nave under one roof, being of opinion that the form of nave and aisles, which is hallowed by so many centuries' use in the Christian church, is also the most convenient for the decent and reverent celebration of our services, for hearing and for economy of space, or rather cubic content. There is however one defect in our system of aisles which we are bound to remedy as far as we can, namely, the obstruction of view caused by the columns. I am aware that many architects think this practically nothing, but I have tried the experiment many times myself, and can therefore assert that in an ordinary aisled church there must always be a large proportion of sittings cut off from the view of either altar, reading-desk, or pulpit. The effect is practically very disagreeable, and, to my mind, inconsistent with the conscientious carrying out of the principles we profess. It appears to me that there are only two ways of overcoming the defect—one by no longer employing fixed seats, the other by diminishing the columns to such a diameter that the slightest movement of the head of anyone placed behind it will bring the minister into full view. The largest diameter which can be employed to effect this is from 9 to 10 or 11 inches. Now it is obvious that such columns can only be safely obtained by the employment of a material which has long been used without scruple for similar work in every modern building except a church,—I allude of course to iron. There seems to be an extraordinary feeling afloat against an iron column, as unecclesiastical and ugly. Now to say it is unecclesiastical is nothing more or less than narrow-minded prejudice; and to say it is ugly is only to acknowledge our own shortcomings in having left it so so long. In defiance of art critics, the civil engineer has long decided that it is good construction, and it is high time for the architect to take it in hand and make it good art. I believe a check has been given to progress in this really grand and almost new field of design, artistically speaking, by the solemn denunciations levelled against the use of iron in architecture (except as a tie) by an eminent authority a few years ago. The argument gravely advanced in support of his views—namely, that we find no mention of iron architecture in the Bible—might as well be used against stained glass in decoration. Whatever may have been the cause, it is a fact that church architects, until quite lately, have appeared to be ashamed of the use of iron as a constructive material. In cases where it has been used for columns, it has usually been from motives of economy, and instances are not wanting (happily no recent ones) where it has been neatly painted and sanded in imitation of stone. If used at all, the material should of course be treated as what it is, and I cannot doubt that, if properly handled and elaborated, iron columns may be made beautiful and attractive features in church architecture. It may be thought a very great innovation to gain but a small advantage, but there is a true principle involved in it. I do not see why an iron column (which cannot have less to do with our ritual than a stone one) should be thought unecclesiastical, nor why it need be ugly; nor do I like to hear distinctly useful and convenient materials and modes of construction objected to simply on grounds of precedent and association. One objection I have heard raised against them is the bad proportion they would bear to the superincumbent walls, but this again I believe to be, according to true principles, simply a question of association. In using a new material in a new position we must create new feelings of association for ourselves. If a few good examples were erected, people would soon begin to get used to the proportion, and to like the thing, as undoubtedly right and full of purpose.

Before leaving the question of association I have a few words to say about church warming. As I just now remarked, we find that this is a most important point, and nothing disgusts a congregation so much as finding themselves in a cold, draughty, or ill-ventilated church, where the ladies cough all the winter, and faint all the summer. You need not fear that I am now going to enter upon any discussion of the best means of warming and ventilating. I merely wish to point out that we perhaps oftener than necessary increase our difficulties, and impair the perfectness of the system adopted, by thinking it right to hide away as much as possible all the paraphernalia of chimneys, &c. For instance, I want a chimney for the vestry and one for the warming apparatus, but I am afraid of making a good stack, and carrying them to the proper height, lest anyone should tell me I have given my church too domestic a character. Ought I not rather to consider, that when we insist on introducing domestic comforts into our churches, that fact must, under an intelligent architect, come out distinctly in the character of the building? Our congregations cannot be provided properly and truthfully with the comforts and luxuries of home without paying for it by the disfigurement—if it be a disfigurement—of their churches by domestic features.

The next consideration, convenience of hearing, has just been so fully discussed by our president in his admirable paper that there is little left for me to say. I fully agree with his remarks on the acoustics of churches, and I was particularly struck with the opinion he expressed as to open roofs and lofty naves, contrasted with a low proportion and boarded ceilings, as completely coinciding with my own conviction on the subject, based on observation and comparison of many buildings. We must recollect that, in making observations on the acoustic qualities of churches, it is not sufficient to go yourself once and try how you can hear at any particular part, as there may be many disturbing causes acting at different times; one of the best tests is, whether it is what the clergy call an "easy church." Inquire of a few clergymen who have done duty there what they think of it in this respect, and you will form a far truer estimate of its qualities than if you ask half the congregation. I believe it is little known how many clergymen's health is seriously impaired by having to do duty, day after day, in a difficult church. It therefore becomes not only a question of convenience to the congregation, but of health and comfort in many cases to the clergyman.

It now only remains for me to touch upon our requirements as to the musical arrangements of a church,—and here let me say, that though it can scarcely perhaps be expected of a church architect that he should be a musician, yet he should make it his business to understand something of the construction of the instruments used in a church. An organ, the most beautiful of instruments when in tune, is one of the most disagreeable when neglected, and everyone should know how sensitive it is to damp and draughts, in order to guard against this in his arrangements for the reception of the instrument. If there is a choir the organ should always be placed close to them, and the proper place for it is either in a side aisle of the chancel, or in an organ-chamber built expressly for it, which is better. The effect of the instrument will be much enhanced, and it will be kept in better tune, if the walls are lined with boarding on battens, and if not in a gallery it should always be raised on a platform some feet from the floor. The worst place for the organ on every account is the west gallery, if there is one, and I believe organs are never now placed there in new churches. Of course I do not contemplate the possibility in these days of an organ appearing over the altar. In small village churches, where an organ can seldom be tuned, I think myself that an harmonium is preferable; it has the advantage of not getting out of tune, and though it has always something more or less wanting in the tone as compared to an organ, it is quite sufficient to lead the singers.

I have now taken a slight and hasty survey of our modern wants and requirements, and the influence they should and must ultimately exercise on our church architecture; and I must beg you to excuse me if I seem to have expressed any opinion too strongly, or if I have dwelt too long on any points which may appear trite, commonplace, or trivial. I feel that I have omitted much that might well and appropriately have been brought to bear on the subject.

DESCRIPTION OF A NEW PORTABLE COFFER-DAM.*

By Capt. E. B. Hunt, U.S. Engineers.

The use of the coffer-dam in laying foundations under water is among the best established and most reliable sources of the engineering profession, and its application in several classes of cases is well settled. In making studies for certain contemplated constructions at Fort Taylor, Key West, a new style of coffer occurred to me, which I hope soon to apply, and which gives rational promise of success.

The first case considered was one of founding wharf and bridge piers on a rock bottom, over which a thin stratum of sand is spread. A set of piers 10 feet square, of solid masonry from the bottom, was first contemplated. For these the style of coffer planned was a strong square frame, with four corner posts, and a sufficient number of wale-courses across the four sides and framed into these corner posts, to give the stiffness of side-wall necessary for supporting the whole water-pressure. The length of the corner pieces would be such as to give an excess of a foot or more at the top in the deepest water at high tide. The size in plan would have to be such as to give the requisite working space, and might be reduced to 15 feet square. This framework being put together, and stayed by a set of diagonal rope tie braces, could be launched and taken to its position, where it would be placed erect and adjusted to be level, using if necessary uprights in one or more angles, to bear on the bottom or to be driven to the rock, and then lashed or bolted to the levelled frame. These angle posts can be sufficiently driven to give security against the force of tides and currents when needed, and also to sustain the weights required to be rested on the top of the frame. The coffer frame being thus fixed in position, a row of sheet piling of sound 3-inch hard pine plank remains to be driven to the rock in contact with the wales, and guided either by two outside timber guides, made to be removable, or by fixed flat iron bar guides, with the angles smoothed.

Now comes the feature which I suppose to be entirely novel, and which gives a peculiar character to this portable coffer-dam. Take strong canvas, and proceed to make up a case or covering for the entire coffer, using two thicknesses of canvas, and interposing a complete coating of mineral or coal tar, so as not only to cause the two canvas layers to adhere to each other thoroughly, but to make a perfectly impervious sheathing. Along the bottom edge of the coffer sheathing a similar double canvas flap is joined around the whole bottom line, which will lie spread out over the bottom as far as is judged necessary. The breadth of flap will depend essentially on the nature of the bottom. The surface to be thus covered should first be raked clear of sticks, stones, &c. to prevent tearing holes through the flat. The case and flap, water-tight through their whole extent, and having much positive strength to resist pressure, being put on the coffer and surrounding bottom, it only remains to proceed with the pumping, which being actively pushed will rapidly reduce the small inclosed water column. As this goes on the exterior pressure comes first on the canvas coating, and this in turn rests against the sheeting piles, and along the entire surface of the bottom. As the sheeting should be of even thickness with straight edges, the joints will be close and narrow; hence there will be no danger of ruptures from the bridging strain across them. The submerged exterior guides being either removed, or formed of iron bars with bevelled edges, would create no dangerous strains. To bring the flap more closely to the bottom, a sprinkling of sand or any clean earth might be thrown over it when in place, or the outer edge might be weighted if needful. In case the water should penetrate through the bottom covering layer, even from the outer boundary of the flap, it is only required to scoop out the inclosed sand, and fill in the bottom with a layer of concrete, as is usual in the common coffer, using the tramis, a plain wooden trough, or a box with a trip bottom.

It only remains to proceed in building the piers, using the top of the coffer as a platform, and to support the derrick or traveller, the materials being lightered alongside. Should a steam-pump be found necessary, this could be worked on board a lighter, by using a flexible pipe, led through the side at the top, or it could be carried through the case and sheathing near the bottom. A series of lashings along the top of the case could be used for fastening it, and buoyed cords attached to the edge of the flap would serve for its manœuvre.

Another mode of treating this case might be preferred for great depths. This is by using a circular coffer, made by trimming to the required arc sweeps of 3-inch planks, combining them in full circle ribs so as to break joints, and fastening with screw bolts. This is merely turning an arch centre into the vertical. Launching one rib, a set of upright struts with drawbolts would be placed on it, and the second rib built on them, &c. In some cases this might be superior to the square coffer. The modification of the case and flap would offer no serious difficulty. Various other timber and iron coffer frames might be advantageously used in treating this case.

In the instance first considered it was desirable not to obstruct the water-way more than was necessary to get the solidity required by a permanent wharf for heavy vessels. A series of these piers giving the requisite support for the wharf and bridge platforms answered these conditions, and it was supposed that this plan could be used in water of over 20 feet.

The facility with which this portable coffer can be struck and established is its great recommendation. Admit the water, hoist the case, draw the sheeting, and float the frame to its next station, buoying if necessary, and then all becomes simple repetition. It is a question of judgment or calculation in each case to give the framework the stability required for resisting the pressures, currents, and wave actions; as also to decide where the probable violence of waves would make the plan impracticable or injudicious. Judgment must also be used in deciding whether the ruggedness of the bottom makes this plan inapplicable. Sometimes this difficulty would be fully met by throwing around the coffer a covering sheet of fine clay or marl, which will either make the bottom tight, or so cushion it that the flap can be used successfully. When we contrast the simplicity of this coffer and the facility with which it can be established and transferred, with the complex character of the ordinary fixed coffers, or with Stevenson's portable coffer, so limited comparatively in its application and so troublesome in erection, it will need but little consideration to perceive the utility of this device in numerous cases of bridge piers and other structures. To extend the above system to larger piers requires only the application of simple well established principles, which every competent engineer would easily make, and which need not be here dwelt upon.

It is likely to find its first application in a sea wall, which will probably be built at Fort Taylor next winter. It is proposed to use in this case a portable coffer of 50 by 12 feet, in five compartments of framing, the intermediate submerged cross bars being made movable. The building of the first section of wall will not much differ from the building of a pier, except that the masonry bond at each end must be arranged to provide for the adjoining sections. In walls but little exposed to the sea, the sections can be brought above low water independently by building plain heads and leaving a clear joint. Of course this would not do where the foundation is bad and the load irregular.

To build this second section, the coffer would be re-established as before, except that the end should be arranged to embrace the walls already carried up, and the sheeting should be shaped to close in neatly on its front and rear faces. The case and flap will have to be so altered at this end as to fit the section of the wall, and extend along its front and rear faces for some distance. In the proposed wall, the use of dove-tailed header and stretcher courses of granite is contemplated for the face, and a massive concrete filling for the back. The box planking for the concrete can rest against the main uprights and can be recovered on striking, thus leaving all the spare space in the coffer for face work.

The simplicity of this coffer, and the facility with which it can be shifted from section to section of a sea-wall, lead me to believe that it would be a great source of economy in constructing the walls of wharfs, basins, docks, &c., when the shelter from waves and character of bottom make it available. In many cases the flap could be nearly omitted, and in some rough bottoms the simple coffer case would be used, and a slight foot slope of puddle or earth, which works tight, could be thrown in so as to serve the purpose.

This device not having yet been tried, I should scarcely bring it before the public, except that I am willing by publication at once to prevent patents, and to give to engineers the benefits it offers, which can be seen beforehand with almost absolute certainty.

---

* From the 'Journal of the Franklin Institute.'

ON ACOUSTICS.

By T. Roger Smith, Architect.

(*Concluded from page* 4.)

Very bright lights remain longer impressed on the eye than the image of ordinary objects, and similarly very intense sounds remain longer in the ear, and consequently fewer repetitions of them in a second are required to produce a continuous note; so that though it is impossible to hear sounds from an ordinary cord making fewer than thirty vibrations in a second; yet Savart has succeeded in making audible a sound composed of only fourteen pulses, or seven complete vibrations, in a second, and at the other extremity of the scale, in rendering audible sounds up to 24,000 vibrations, or 48,000 pulses per second. The greater or less frequency of the vibrations occasions the sound to be more or less sharp, and the actual correspondence between the number of vibrations in two notes determines their concord or discord when sounded together.

For example, the lowest C on a grand piano is said by Brewer* to require 32 pulses in a second for its production; the sound most accordant with that is its *octave*, the number of whose vibrations always bears the relation of two to one to those of the original sound. Thus, in the instance just selected, 64 vibrations in a second are required to produce the C an octave above the one we started from. When a note and its octave are sounded together, every vibration of the fundamental note coincides with a vibration of the higher one. If G, the fifth above this C, had been substituted for the octave we should have struck a note containing 48 pulses in a second, along with the C containing 32 such pulses; that is to say three pulsations of the higher note to every two of the lower one; and, only every other pulse of the fundamental note would have coincided with one of the upper ones. This is the next most accordant interval.

The relation between a note and its major third is expressed by that of 4 to 5 or 32 to 40, so that this interval is less perfectly consonant.

Two notes, the pulses of which hardly ever coincide, sounded together produce a discord. For instance, the seventh above any note bears the relation to it of 15 to 8, and this is consequently a very imperfectly consonant interval.

Beyond just stating that all natural sustained sounds are produced by the vibrations of elastic substances, it is impossible to enter upon the very complicated and very interesting investigations that Chladni, Savart, Wheatstone, and others, have conducted upon undulation and vibration in all its forms, or to describe to you the elegant experiments by which the motions of vibrating bodies are rendered visible.

The transmission of these vibrations through the air is, however, a matter of some moment to our subject. Each impulse of the vibrating body makes an impression on the air immediately adjoining it, which impression immediately passes onwards and outwards, leaving the atmosphere behind in a state of quiescence. A wave of sound is in fact a state of momentary compression travelling with the speed of the wind away from its exciting cause into space; and it is accompanied by a displacement of particles, slight indeed, but still actual, and in fact when the impulse has lost the power of moving the air at all it ceases to exist. Should this wave meet with an obstacle that reflects it, it will travel back through the atmosphere to any point to which it may be directed by the reflecting body. Any agitation of the air which from circumstances, such as reflection for example, is made to take the form of regular pulses, will, if these are but frequent enough, become an audible sound. Take a familiar instance.

Suppose we have a pipe, of any length shorter than about 35 feet, closed at one end, and make an agitation in the air at the open end. As long as the separate movements are so far apart that the impulses leave long intervals between them, no sound is heard; but as soon as the movement is brisk enough for a pulse, the moment it has travelled to the bottom of the pipe and back, to be followed at once by another, an audible sound will result, the pitch of which depends on the length of the journey each pulse has to make down the pipe and back again. If we go on making the agitation more brisk for a time, no alteration except in loudness will be audible, the pipe seeming, so to speak, to keep the agitation that wants to enter it waiting till the one that is there emerges. But suddenly the sound heard will jump an octave, and we shall find, if we take the proper means of investigating, that the air in the pipe has divided itself into two vibrating lengths. Increase the agitation, and soon another jump takes places, the air in the tube dividing itself into three portions, and so on,—the points of division being termed *nodes*. Thus for example, by blowing more or less violently into an organ-pipe we can produce either its fundamental, or the octave above that note (which is the sound proper to a pipe of half the length, or to the original pipe divided into two portions by one node), or the twelfth above (which is the sound proper to a pipe of one-third the length, or to the original pipe divided into three portions by two nodes), and so on. These divisions equally occur in vibrating strings, and it is remarkable that even where a string or a pipe is sounding the gravest note it can emit, a second set of vibrations almost invariably coexists along with the primary ones, giving out the octave, twelfth, &c. These sounds are called *harmonies* of the principal sound, and an acute ear can detect their presence constantly, perhaps nowhere so readily as in the note of a large bell.

It becomes of importance to us to know all these circumstances, if we reflect that any room may be regarded as nothing else than a great organ-pipe, in which if a suitable agitation be roused, sounds no doubt will be emitted by the air. Nor is there any safeguard in the size of the room; for although a room be too large for what would be its primary note to be audible, the harmonies of that note—some of them—will be quite appreciable; and it is the presence of these that causes what is known as the *note* proper to a room. As this note cannot ordinarily be avoided, the only thing to be done in relation to it is to see that the dimensions of the room each way bear some simple numerical relation to one another, so that if undulations are roused that travel from end to end, and others that travel from side to side, the sounds due to the two may blend harmoniously, and not clash discordantly.

The last point to which I have to draw your attention is the sympathetic vibrations that sounds can excite in sonorous bodies. If a tuning-fork is sounded in the air its note is extremely feeble, but if it be rested on a pianoforte or a table, a marked alteration in sound is audible. Half-a-dozen tuning-forks of different pitch, tried in succession, will all rouse the same phenomenon, and the truth is, that small as they are, each one has set the entire material of the pianoforte or the table in vibration, and that too in accordance with its own rate of motion, so that the whole table or the whole piano has become for the moment a part of the tuning-fork, and is emitting sound in unison with it. If we now vary the experiment, and hold our different tuning-forks near the open end of an organ-pipe or flute, we shall not get the same uniform result. Those forks which emit the sound the pipe or flute would emit if blown into, or one of its harmonies, will be found to set the air in the tube into sonorous agitation, and the note they emit will be greatly reinforced; but the other tuning-forks, whose note is not related to that of the pipe in question, will be found to have only a trifling influence, if any, over the air in the tube, and their sound will not be perceptibly reinforced. Thus we arrive at a fact of the greatest importance, namely, that some vibratory bodies will move in unison with almost any sound, while others voiced to emit a particular note will reinforce that note, or those related to it, but will be useless or almost useless as regards other notes.

II.

It now becomes desirable, having considered some points relating to the nature of sound and its transmission, to ask, What means have we of influencing sound in a building?—and what obstacles is it likely to encounter there compared with what it would meet with in the open air? There are two familiar instruments in everyday use, and a third some forms of which are also well known, which supply a sufficient answer almost without words to the first question, namely, What means have we of influencing sound in a building? The two instruments I first alluded to are the violin and the speaking-trumpet; the third is any common reflector, say the sound-board of a pulpit. If we take any familiar sounding object, such for instance as a watch, and note to how great a distance its beat can be heard in a room, and then place it successively in the mouthpiece of a speaking-trumpet, in the focus of a parabolic reflector, or against the body of a violin, we shall find that in each case we have influenced the sound; and, so far as I know, we have no possible means of influencing the sounds emitted in buildings except such as bear an analogy to one of these three.

---

* Whose numbers do not precisely correspond with those given by some of the French writers.

There will be something to be said by-and-by about impediments and the avoidance of them; for after all, except in extraordinary cases, the whole secret of success in building for sound lies in simply doing as little harm as possible; but as far as assistance to sound goes, I repeat, we cannot get beyond the teaching of the mirror, the speaking-trumpet, or the violin.

To return to the watch; we shall find that both the reflector and the speaking-trumpet cause its tick to be heard much more loudly at the same distance, or to be audible to a much greater distance than when uninfluenced, but only in one direction. The person to whom the trumpet is pointed, or towards whom the mirror faces, gets more sound, but a person at the side gets less. Were the sound of such a nature as to be capable of being closely examined, it would be found in both cases to be deteriorated in quality of tone; and I am inclined to think more so by the reflector than by the speaking-trumpet; and in each case, if articulate or otherwise very sharp and defined, it will have lost a little of its distinctness.

If now we take the violin and place upon it the watch, we shall find that the sound will be audible at a greater distance than when the watch is by itself; but will not be (as in other cases) confined to one direction only. It will not probably extend in any direction so far as the trumpet would throw it, but will be much more equally heard; while—and this is the great point—whatever change takes place in its character is entirely for the better. None of its distinctness is lost, but its tone is improved; and should the violin be a very fine one, and something with musical sounds be substituted for a watch, the effect on the quality of the sound will be very marked. A string, for example stretched to sound a certain note, and excited by a violin bow, will give out its proper note indeed, but its voice will be poor, thin, and weak. Transfer the string to the instrument, draw the same bow across it in the same way, and the note of the string, reinforced by the vibrations of the body of the instrument, will be something totally different, incomparably finer, and yet identical in pitch and sharpness.

We ought then, in building for sound, to take a lesson from each of these instruments. What are their peculiarities? In the reflector and the speaking-trumpet the influence upon sound is almost wholly a matter of form. In the violin it is also no doubt a matter of form, but as much if not more a matter of materials combined with form.

We gather then that we may, as in the speaking-trumpet, impress an initial direction on sound as emitted, and guide it forward, or that we may aid its progress by reflectors behind or above the speaker, but that if we want to support or improve it we must have recourse to the resonance, or sympathetic vibrations of some sonorous body, capable of lending itself to all the varieties of sound produced near it.

The common sounding-board often fixed over pulpits acts as a reflector, but usually (being made of thin wood) as a resonant reflector, a much less dangerous neighbour than a hard smooth surface of plaster or stone, which has the disadvantage that it reflects a sharp and somewhat spoiled echo that travels in the same direction indeed as the primary sound, but is a little behind it and seems often to mar its distinctness.

It will be readily understood that a slanting reflector overhead, to beat downwards and forward rays of sound that would otherwise escape towards the ceiling and be lost, is likely always to do good, and can in no case be so injurious as one behind the speaker; and it need scarcely I think be added, that the only reflectors that can be of advantage are those that throw the sound forward in the same direction as that in which the speaker is speaking. An echo reflected down from a high ceiling, or worst of all back from an opposite wall, will always be disagreeable.

It may be more appropriate here than afterwards to notice a curious application of the reflector to pulpits, which was some years ago rather extensively made use of, and is illustrated in the model before you. It appears from a pamphlet published by Rivington in 1829, entitled, 'Description of a Parabolic Sounding Board erected in Attercliff Church, by the Rev. John Blackburn,' that this church is a parallelogram, 95 feet by 72 feet, and 56 feet high, with an elliptical recess 32 feet wide by 10 feet deep for chancel, and the pulpit placed in the centre of the centre aisle in front of the chancel. There is no clerestory, but there are pillars supporting a gallery. In this church it was impossible for the preacher to make himself heard, and after shifting about the pulpit in various directions with no marked advantage, he determined to erect behind the pulpit a sounding-board like a hood—parabolic in section, with his head in about the focus of the parabola. He relied upon the property of that curve to reflect as parallel a series of rays diverging from the focus, and he adds that the results exceeded his most sanguine expectations. The congregration were now able to hear the preacher, and the remote seats of the church became some of the best. The inventor of this expedient was Mr. Blackburn himself, and he brought it before the public in this pamphlet, which is admirably and scientifically written, and also laid it before the Royal Society and the Society of Arts. With the last-named society he deposited a model, which has since passed into the possession of the London University College, and it is by the courtesy of the secretary of that college, and of Professor Potter, that this model, which is the one before you, is intrusted to me for this evening's paper.

To proceed, however. In the Society of Arts Transactions I find two letters from Mr. Farish, then Jacksonian Professor at Cambridge, who had had one of these reflectors put up in his church. He reports most favourably both upon Mr. Blackburn's reflector and his own, saying that the sound is improved in *every* part of the church, and especially the more distant parts; but he alludes casually to inconveniences that had been supposed to exist, and says they are of no consequence. This seemed like a flaw in the case; and as the point appeared of great practical interest, I obtained, through the kindness of Mr. Holland, of Sheffield, full particulars of the subsequent history of the reflectors; and, not to trouble you with all the details, found the main facts relating to them to be these:—

First, I find the reflector has been pulled down from Attercliff Church, partly because it was unsightly, partly because the present incumbent can do without it, and partly because the inconveniences attending it were felt very trying by most preachers; though the inventor either was not annoyed by them or endured them cheerfully for the sake of the real benefit he derived from the reflector, but some of the casual occupants of the pulpit found them so trying that they used to prefer preaching from the reading-desk. The disadvantages were—first, that the speaker heard every word uttered in every part of the church; and secondly, what was worse, had every word he himself uttered dinned into his own ears; and lastly, that to do any good with the reflector he was obliged to keep still, with his head in or near the focus of the parabola. One of the neighbouring clergy preaching in the Cambridge church states that he was at once amazed and amused at the distinctness with which he heard the whisperings of the charity children in the remotest part of the west gallery; and the converse of this transmission was true, for a watch placed at the focus of the parabola could be heard to the very end of the church.

As regards the general application of these instruments I find that the carpenter who made the original one himself made and fixed no fewer than twenty-nine of them, including two at Oxford, one at Cambridge, one at Trinity Church, Huddersfield, one at Duckinfield, near Manchester, and one at St. Sepulchre's Church, Smithfield; perhaps members can inform us of the fate of some of these. Also I find that at Darnall, near Attercliff, the end of the church was built in a parabolic shape, and the pulpit fixed in the focus. The preacher in this church is satisfied with the effect, but occasional preachers, some of them, dislike it. Lastly, I got information of one other church at Sheffield where the reflector had been put up and made use of, and satisfied the clergyman and those persons who sat in the centre, and at the end of the church, but the people at the sides heard worse than before and complained accordingly; so much so that it had to be removed.

From these facts—which I hope I have not unduly extended—we may gather that the parabolic reflector possesses such disadvantages that it would never be safe to build the end of a room of that shape, and that in most instances it will be inadmissible even as a palliative in bad cases; but that on the other hand it does enable persons remote from the speaker to hear well, and therefore in a church or room that was long and not wide, it might be valuable if the speaker is not nervous, and does not employ much action. I need not add that it can hardly fail always to be frightfully ugly.

We pass now to consider the speaking-trumpet and the analogy it may bear to a room. The action of the speaking-trumpet was for long attempted to be explained by the theory that the sounds were reflected across and across from side to side of the tube, and somehow got ejected nearly or quite parallel in the direction from its mouth. But this theory fails in many ways to account for the phenomena of the speaking-trumpet, and M. Hassenfratz, the great authority on that instrument, declares that all his experiments led him to the conclusion that the effects on sound produced by the speaking-trumpet are due to a different cause. The air contained in the interior of the instrument, he maintains, being inclosed by its walls is compressed by the vibration of the sonorous body in a more vigorous manner than would be the case if the walls had no resistance; consequently each individual particle of this air contracts a greater amplitude of vibration, and is capable of transmitting that action to a greater distance before it becomes entirely lost than it would in the open air.

Now all this applies, *mutatis mutandis*, to a public speaker in a room. If you set him up in a spot where a great height over his head swallows up the sound above him, and vast spaces open on either side of him and behind him, the power of his voice is wasted in communicating vibratory motion to these masses of air as well as to that mass which lies in the direction where the auditors are.

If now, avoiding the extreme of cramping and confining the space too much, you set your speaker under a low roof which rises as it goes away from him, and in a recess that widens as it joins the main building, you procure him the advantages of a speaking-trumpet, and throw his voice forward by preventing it from losing itself above or behind him. And it must further be remarked that if you want your speaker to be able to address a very numerous audience indeed, you must effect it, not by enlarging the building very greatly in every direction, but by extending it in the direction towards which speech is directed —namely, forwards—with only such additions of height and breadth as are necessary to prevent the structure from failing through disproportion.

Turning now to the violin, we find its peculiar effects are due to resonance. As to the methods of procuring resonance we have seen that a body of air in a room will reciprocate certain sounds, and we find in certain buildings that the air will reciprocate any musical sounds emitted, but with the disadvantage that it continues to sound them for some time after the original musical notes have ceased. Canterbury Cathedral is the finest instance of this sort of resonance I have heard of. Westminster shows it also. Beautiful as is the blending of sounds and richness of tone due to this cause, it is of more advantage to church music than to reading or speaking, as you may readily notice at Westminster. In ordinary public buildings a large mass of empty space is to be avoided, not only because the air in it absorbs part of the power of the voice, but also because it may be resonant in an undesirable way. The employment of thin planks of wood for procuring resonance is not open to the same objection, and nearly all the most celebrated acoustic buildings known will have been found to be fitted up to a great extent with wooden lining.

A floor on columns, with a hollow space under it, and a ceiling with a hollow space above it, are both adjuncts to resonance. It is to be remarked, that the presence of auditors in a room deadens the sound so much that if a building be such as to afford, when full, the greatest possible assistance to music and to the human voice, it is more than likely to have a very decided reverberation when empty.

III.

Let us now for a moment ask what *harm* we can do to sound; what impediments a building may present to its propagation; and how far in a new building we may avoid those impediments, or in one where they already exist, may neutralise or remove them? The principal causes that will have an unfavourable influence on sound in buildings are echo, reverberation, obstacles, and unshapeliness or bad proportions.

Echo is, where it exists, one of the most formidable blemishes possible in a room, for it asserts its unwelcome presence with every word that is spoken. The presence of a flat surface at a considerable distance from the speaker or musician and facing him, is very much to be avoided, as apt to echo, and consequently in almost all good public rooms the end farthest from the platform is curved or recessed, or otherwise broken up, or has a gallery thrown across it, the front of that gallery being carefully arranged so that either it shall not echo or shall reflect the sound to where there is no auditory. In case of an existing echo the best remedy no doubt is to break up the surface of the reflecting wall in some such way as this. Where expense or other difficulties prevent this remedy being applicable, to hang up draperies which may mask and break up the offending surface is good. In over-lofty rooms an echo is often perceived from the ceiling downwards. Such a one exists very decidedly in the new reading-room at the British Museum. Should the echo however be indistinct or very much broken up, or should there indeed be a noise but not amounting to a regular echo, the disturbance is called reverberation.

The excess of resonance in an empty room often causes reverberation, and may be generally cured by covering those surfaces which reflect sound with soft substances. The audience frequently do it, but if not, the gradual addition of carpets or matting, or hanging up drapery, will proportionately deaden the excess of sonority in the room until a proper pitch of distinctness is gained. In a church in the north, where the reverberation was unpleasant even when there was a full congregation, the desired quiet was I am told quite gained by laying down matting over the aisles and other open spaces. Open skylights are very apt to reverberate, so are deep and square window recesses, and both ought to be avoided where sound is of great importance. Lastly, damp walls reverberate much more than dry ones, and in a new building it may often be as well to hang up a little drapery for a few months, which can be safely taken down when all gets quite dry.

The next unfavourable agency named was that of obstacles. Sometimes in buildings of some size obstacles in the shape of columns not only may be tolerated, but will bring beneficial results after them, on account of the good they do in breaking up or cutting off vacant spaces. This is particularly the case with the columns in churches, which, obstacles though they may be to direct sight and hearing, often help to prevent reverberation, and always are essential to that system of construction, with a nave and side aisles, which is not only ennobled by ancient tradition, but also found to suit well with modern requirements. The most serious obstacle to comfort in hearing is the interference of some one's head between the auditors and the speaker. Where the speaker is not very high up indeed, and the audience occupy a level floor of any great extent, the inconvenience from this cause is much felt, and some partial elevation of the back of such floor is often attempted.

The method of securing an undisturbed ray of sound and line of sight for each auditor was first published by Mr. Scott Russell,* and has since been re-described and illustrated by Lachez, though it appears to have been practised more or less perfectly by the Romans. It consists in a system for setting out the height of the seats by which they fall into a curve, called by Mr. Scott Russell the *isacoustic*, or equal-hearing curve. The mode of procedure is as follows:—Having a section of the room, and having determined the position of the speaker and the seats, you proceed to determine the height at which you will place the speaker above the first auditor; this settled, draw a line from the speaker's mouth, and let it touch the point where the top of the head of the first auditor ought to be. This will fall on the line marking the position of the second auditor, and you fix the height for his seat so that this visual line will come below his eye or ear, for this allowing some average dimension. From the point thus obtained set up a height which will give the top of the head of this second auditor, and so on. The dimensions that Lachez advises to be followed are—

	Metres.		Ft. In.		Ft. In.
Back to back of seats	0·60 to 0·75	=	1 11⅝	to	2 5½
Height of seat	0·45	=	1 5¾		
Mean height from top of seat to eye	0·75	=	2 5½		
Mean height from eye to top of head, not less than	0·15	=	0 5$\frac{9}{10}$	say	0 6
Better as much as	0·30	=	1 0		

Mr. Scott Russell recommends for face-room, or the height from the mark for the supposed position of the eye to the top of the head, an allowance of 18 inches. The nearer to the front seat the object to be seen or person to be heard is placed, and the lower it is, the more steep will be the inclination of the seats. The further removed and the higher elevated the object is, the less steep will be the curve, which even dips down in such cases at the commencement of its course. The seats in the Handel Orchestra at the Crystal Palace will give a good idea of the incline of this isacoustic curve.

---

* In the 'Edinburgh New Philosophical Journal,' vol. xxvii. for 1839.

There is a great advantage beside the direct radiation of sound to auditors thus placed, and it is that they are almost of necessity free from the effects of echo. To make a stepped arrangement of seats perfect they should be arranged on a sweep on plan, and thus every auditor will have his face directed towards the speaker, will have an uninterrupted sight and hearing, and will be free from echo at his back, for if any such echo exists it must pass over the heads of every one but those in the very back row of all.

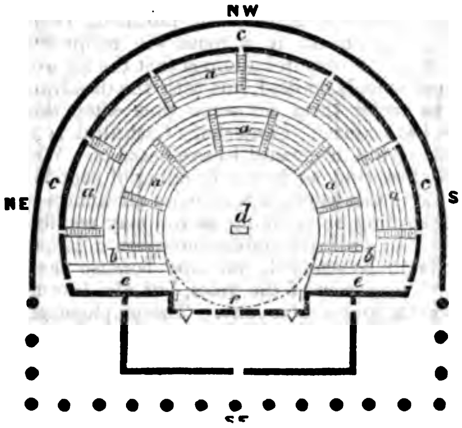
The remaining obstacle is unshapeliness and bad proportion. That a disproportionate room is bad for sound is a fact long since admitted, and holds good whether that room be large or small; but when this has been said, and experience has been appealed to for confirmation of the fact, there is very little that in the present imperfect state of architectural acoustics can be added. The subject has been alluded to before, and the most probable explanation of what is an admitted truth was then given, namely, that if all the dimensions are not in proportion to one another, the note of the room will not be good and pure. It is very possible that in time we shall know this for certain, and shall know too what precise series of numbers are best for dimensions, so that a room may be "voiced" beforehand like a bell, or an organ-pipe, by calculation, but we have not reached such knowledge yet.

In connection with proportion however, I ought to draw your attention to the great division which seems to obtain between buildings for sound. There are no doubt two main divisions of speaking places, in the one (of which an ancient theatre is the type) sound is directly radiated from the speaker to the hearer much as in the open air. These should approach a circular or semicircular shape, and an equal dimension in every way. The second sort are those where the form of the building combines with the initial direction of the sound, or imparts such an impulse to it, and conducts it onward in one direction. The majority of large rooms are of this class. Probably, therefore, one or other set of forms and proportions must prevail. If the building is to be on the radiating principle it must be constructed so as to avoid reflection of sounds, and may be lofty, but must approach a semicircle or circle on plan. If conduction is to assist, then there must be one dimension decidedly predominating over the others, and that dimension should be the length away from the speaker, and should regulate the width and height, with the proviso that in these buildings the proportions should be rather long than short, and rather low than high.

With one example of an influence upon sound in galleries and long rooms, which is unquestionably due to the proportions of the room, and will be modified by every modification of those proportions, we shall have done with the topic. It must have often occurred to persons listening to music in a tolerably long hall or gallery, to notice that there are portions where the sound appears more distinct than in others. This was very noticeable in the Floral Hall at the time concerts were given there, and may, I understand, be detected in St. James's Hall. This phenomenon coincides with an interesting investigation of Savart, published by him in the 'Annales de Chimie.' He invented an apparatus for showing visibly the actual condition of the air in a room during the time that a continuous sound of great intensity was kept up, and I mention this investigation not as having been pushed so far by him as to lead to any practical result, but rather as showing that methods exist by which we may, perhaps, be able to arrive at information as to the acoustic condition of the air in rooms to a degree hitherto unattempted. The sound employed in this investigation was that of a bell fixed in front of an open cylinder of such dimensions as to be suitable to reinforce powerfully the note of the bell, and a sound was obtained by this apparatus of such intensity as to be hardly bearable. The effects of this sound upon the air was made visible by a sort of artificial ear formed of a thin membrane stretched tightly over a small wooden frame, and sprinkled lightly with sand. This membrane when near the bell became excited, so that the sand on its surface was thrown into an agitation, but on moving it to and fro along the room places were found where the agitation varied—in some parts it became very intense, in others very moderate, and in exploring every part of the room it was established that the points of greatest intensity formed a spiral line, making several revolutions during the length of the apartment. On opening an end window this spiral could be traced as continued into the air beyond for a considerable distance. The distance from one turn of this spiral to another was not equal to the length of the undulation proper to the note sounded; it became greater the larger the apartment, and in a long gallery approached the length of the sound-wave. When the windows in a chamber were opened the position of this line of loudest sound—which by-the-by was distinctly perceptible to the ear, as well as visibly demonstrated by the moving sand—was altered, but moving about the sounding apparatus from one part of the apartment to another did not cause any such alteration, which seems to show that this property of a room, if once decidedly manifested, cannot be altered by moving the position of the speaker, but will only be affected by changes in the room itself.

IV.

We have now got together some few materials for the design of an acoustic building. Let us for a little consider how they have been applied or can be applied to various descriptions of structure, commencing with an inquiry how far the simple consideration of size ought to modify the treatment. The safe limit of direct radiation can only be very approximatively ascertained; but comparing the results obtained by Saunders' experiments with observations of that accomplished philosopher as well as architect, Sir Christopher Wren, we may say approximately that if we were to inclose a space not exceeding 70 feet in length by a somewhat smaller breadth, we should be quite safe in presuming that the natural radiation of a human voice of ordinary power would reach all the audience without any assistance, when the speaker was placed in the best position for being well heard, provided always that we were able to insure that no echo from any part of the walls should interrupt. Should our building be much larger than this size it will become desirable to assist if practicable the voice of the speaker. If we apprehend a considerable interference of any obstacle with the sound, this may be too great a dimension to be safe. If, on the other hand, circumstances are all favourable it may perhaps be exceeded.



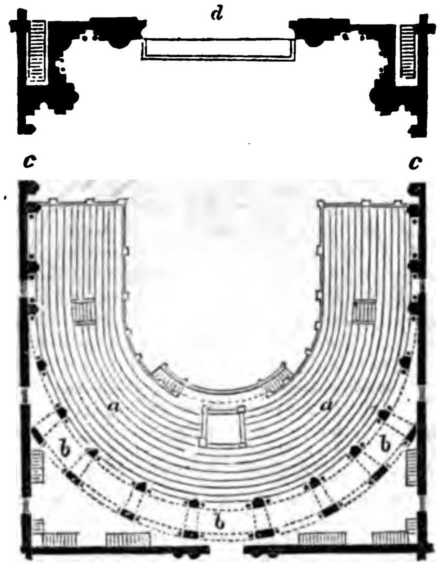
PLAN OF GREEK THEATRE.

a. Seats. *b.* Passages. *c.* Covered portico.
d. *Thymele,* or altar of Dionysus, in centre of orchestra, which was open to the sky.
e. Broad passage, forming part of orchestra. *f.* Stage.

The conditions under which a single speaker can best address an auditory depending upon direct radiation have been already referred to. The building should have a circular outline, and be in extent something more than a semicircle. The seats should rise one above the other, and the speaker should be pretty well forward among his auditors, and the remotest auditor should not be beyond the limits of direct radiation. The most perfect type of these buildings seems to have been an ancient Greek theatre, especially if we bear in mind that the chorus, which occupied the most forward part of the stage, was the most prominent feature in the earlier Greek plays. In modern buildings this form has unhappily gone out of fashion, except for scientific lecture theatres; but there is one fine example in the great Handel Orchestra at the Crystal Palace, the appearance of which when full will convey some idea of what the auditorium of an ancient Greek or Roman theatre must have been when crowded with people. Roman theatres differed from the Greek ones in the auditorium not exceeding a semicircle in extent, and in being constructed, even down to a late period and when of large size, of wood, the resonance of which material was, as Vitruvius tells us, relied upon to reinforce the sound; consequently the *echeia*, or brazen reinforcing jars introduced into Greek theatres, were not adopted in Rome. There has been much controversy about these *echeia*, and those who wish to know all about them will do well to consult the Dictionary of the Architectural Publication Society. It may be sufficient to observe that though in all probability the resonance from them would not have flexibility enough to reinforce speaking, it would be admirably suited to strengthen the effect of slow, sustained declamation, especially if that declamation were of the character of a musical recitative or chant; and if, as seems probable, the principal parts of a Greek drama partook of this character, we cannot doubt that the vases would be a real assistance.

Among English lecture theatres that of the Royal Institution in Albemarle-street has always been deemed famous. It resembles the Roman theatres in being constructed of wood; its seats are arranged on a curve similar to the isacoustic curve, and its dimensions are very nearly indeed in the relation to one another of 2, 3, and 4. Its outline presents a semicircle of 30 feet radius, with the ends prolonged 15 feet, and the ceiling is flat, the wall behind the speaker being flat also. One great advantage in this building is the comparatively small volume of air it contains; the favourable form and proportions help it, but it no doubt draws much of its excellence from the resonance of the wood employed in its construction.

Lachez, in his pamphlet, gives views of all the principal lecture theatres in Paris, and points out that most of them are defective through having too vast a space above and behind the speaker, and he shows that if we wish greatly to extend the space of such an auditory, the walls should radiate from a point behind the speaker's head, and the ceiling should also be lower where he is than elsewhere.



PLAN OF THEATRE AT PARMA.
a. Seats. b. Corridor. c. Space for processions, &c. d. Stage.

All modern theatres for dramatic performances depend mainly, though not exclusively, upon direct radiation. In one of the most celebrated and most frequently quoted examples however—that at Parma, the form was such as to favour conduction as well as radiation, while the resonance of material, constructed as it was internally of nothing but boards even to the ceiling, no doubt helped the sound very much. The Parma Theatre is connected with the Ducal Palace, was built in 1618, and so far back as 1790 was in a state of decay. It must not be confounded with the modern Teatro Ducale at the same city. The dimensions of this building were considerable; its length from the front of the stage to the back of the gallery above the stage was 130 feet, and the width 102 feet, the general form being an oblong, rounded off opposite the stage, and the seats being arranged amphitheatre-wise in steps. Notwithstanding the great size of this house a low voice could be heard in every part, even if the speaker were as much as 10 feet back, making the distance from speaker to hearer 140 feet.

Of more modern theatres perhaps not one is so famous for acoustic effect as the Opera-house in the Haymarket, which was brought to its present form internally about 1790. Here again we have considerable dimensions, though not at all equal to those at Parma; but we have the entire interior constructed of wood, the ceiling of wood, and the stage brought so far forward that a singer may be almost in the middle of the auditory, and may be heard by all of them directly; the orchestra of course is even more among the auditors. The stage is, behind the curtain, extremely shallow, and the auditory is a little more than a semicircle prolonged by two almost straight sides, which approach each other as they reach the proscenium. The ceiling is an extremely flat curve over the pit, brought down above the stage to throw the voice forward, and there is a hollow, unoccupied space above it. Altogether the form is undoubtedly favourable to sound in a high degree, the space above, behind, and at the sides of the singers is restricted as much as possible, and gradually swells out in the part where the sound is wanted to expand, while the division of the boxes, which do not radiate from the stage, would prevent any echo from the back wall, and break up any wave of conducted sound. More important however than the form, in all probability, is the use of resonant materials and resonant cavities, and the entire absence of plastered surfaces.

There is one other group of public buildings which peculiarly require to be treated on the amphitheatrical plan, but which hitherto have always exhibited a sort of unsuccessful compromise on their arrangement. I allude to courts of justice. It is very desirable that the general public should hear well, and they have therefore usually been ranged on steeply-inclined benches, but this has ordinarily been done in a square and often a cubical room, so that all the disadvantages of the square corners and of undue height above the very persons to whom perfect hearing is essential, are retained. In most old law-courts various contrivances for contracting the space above the bench are visible, but it would be a much better construction if the court were from the commencement arranged so that there would be a fair prospect that those who *must* hear would hear *perfectly*, and that all others present would hear well. The moderate size of our law-courts points to the principle of direct radiation of sound as the one on which they must be constructed. The basilica on the other hand, the form anciently employed for the same purpose, introduces us to the consideration of the second great division of buildings, namely, those where the transmission of sound is assisted, and whose peculiarity is that they are oblong. These divide themselves naturally into buildings with a nave and aisles, and simple large or small rooms.

It will be perhaps desirable to consider first those buildings with nave and aisles, of which the basilica may serve as a type, and afterwards to notice large rooms ceiled in one span, and small rooms. In the large cathedral churches of mediæval times, where the object was not simply to build a church just as large as a single speaker might fill with his voice, but to raise a monumental pile for ceremonials, it was of no moment that the resonance of the air contained in the building should be great, so long as it did not destroy the effect of music; and these buildings afford accordingly a wonderful illustration of the sonority of a large body of air, but very few of them are easy to fill with a distinct spoken utterance.

In Protestant churches of more moderate dimensions the main object is that read and spoken words, delivered from the reading-desk, the pulpit, or the altar, should be perfectly audible to the congregation. How far does the ordinary arrangement of nave and aisles effect this? There is no question that the columns inseparable from such an arrangement interfere with direct sight, and partly with direct hearing; but I believe it will be generally admitted that the advantages attendant upon their use more than counterbalance this disadvantage. I have stumbled upon a passage on this subject in Mr. Denison's lectures on church building, in which I think you will be able for once to concur with that gentleman. "It is at last discovered," says he, "that so far from the pillars, and aisles, and broken roofs of Gothic churches, built after the fashion of the old ones, being worse for hearing in, they are generally better than the wide-spread buildings, all under one span like a railway-station, which it was the fashion to erect in large towns a few years ago. This fact is noticed in two recent reports of the Church Building Society, and I had observed the same thing myself in several instances, even in small churches, though without knowing that it was general before I read it there. Certainly some of the worst places for hearing in that I know are buildings all under one roof, and of far less capacity than many churches, both old and new, of the nave and aisle construction, in which a large congregation can hear perfectly well; so that in this as in many other things, the old Gothic builders knew what they were about a great deal better than we do."

The system of open roofs of a high pitch, so as to accord somewhat with the Gothic character, and carried from wall to wall in a single span, had been some years ago employed a good deal for dissenting chapels, and many instances have occurred where these places are bad for hearing—in some instances to a serious extent. The English Chapel Building Society is now employing its efforts to promote the erection of buildings divided by columns of small diameter into a nave and aisles, even where the size of the place of worship is but small.

The position of the pulpit in churches and chapels with nave and aisles is of considerable importance. In chapels for dissenters it is usually placed in the centre of the end of the building, with the communion-table in front of it. In churches it is almost necessarily placed at the side, principally that it may not intercept the sight of the chancel and hearing of the communion service. There is however another quite as good reason for this position, which is that a centre aisle is almost essential to the decent arrangement of a church, and it is in the highest degree unpleasant to a speaker to have the empty bareness of the aisle in front of him whenever he lifts his eyes, while it is equally unsatisfactory to the congregation to see their minister as nothing better than a dusky shadow, projected on the light of the east window, before which he necessarily is fixed if his pulpit be central. Is this position acoustically bad for the pulpit? and (whether at the centre or the sides) should the pulpit be far forward or not?

In answer to these inquiries it seems clear that if the building be thoroughly good to speak in, it will not be so very material where the pulpit stands; but I have no doubt that in doubtful or bad cases, especially where there is echo, the side position of the pulpit is much more likely to prove advantageous than the central one, and on that ground is to be recommended even for dissenting places of worship, for the voice being naturally directed towards the main mass of the congregation will be sent, not straight against the end wall, but obliquely against a side wall.

It is, I believe, always bad to place a pulpit directly against a wall. The practice of Sir Christopher Wren, followed by many good architects, is to put it forward some distance into the nave. Others withdrew it into the chancel, or under the chancel arch. The choice between these two positions must depend rather upon the shape of the church. If it be nearly square, so that the hearers can be grouped round the preacher on the direct radiation principle, I would put the pulpit forward among them, and place it against a column, as is done in the great Continental churches. If the church be long, and the hearers must be reached rather on the speaking-trumpet or conduction principle, the pulpit will probably answer best drawn back under the chancel arch. If there are transepts, and a difficulty is found in making people in the nave hear (and this often happens with transepts), it will be quite worth while to try drawing the pulpit back a little into the chancel, for it generally happens in these cases that the communion service read from the altar is better heard down the nave than either the prayers or the sermon, owing to the initial direction which the parallel walls of the chancel impress on the sound.

Wren's churches, it seems to me, may be studied as models of arrangement for church-building in large towns; the more so because, while Classic in style, they follow the forms of Gothic churches in plan and section. It is remarkable that, notwithstanding his unrivalled constructive skill gave him every inducement to erect a wide roof, he has not, so far as I know, left a single church without columns in the interior, except only the very smallest. In almost all cases he has placed the pulpit some way down the nave; and all the proportions of the cross-section, while they avoid the vice of being cramped, present a certain general impression of lowness when seen in a drawing.

It seems agreed that except in excess, the timber trusses of open timber roofs are advantageous, on account of breaking up echoing surfaces; but I fancy that so far as it goes the sharp angle the two sides of such a roof make at the ridge forms a noisy sort of trench, and that a better effect is obtained where a wooden ceiling is thrown across at the level of the collar, or higher. This will partly depend on the proportion of the church. Galleries are, if properly inclined, not bad places to hear in, but the spaces under them are, unless the galleries are shallow; this especially applies to side galleries, an end gallery may safely be deeper. Such a gallery sometimes helps to prevent an echo, or the introduction of one will often check an existing echo.

On church building, finally, we have among old authorities, not only the practice of Sir Christopher Wren, but his recorded opinions, embodied in a letter, from which had time permitted I would have made an extract. The document in question is to be found in the 'Parentalia,' and expresses Wren's conviction that 2000 was about the extreme number that could be accommodated in one church, which he prescribes ought not to exceed 90 feet long by 60 feet broad. He observes further—"A moderate voice may be heard 50 feet distant before the preacher, 30 feet on each side, and 20 feet behind, and not this unless the pronunciation be distinct and equal," and from this starting point he seems to have regulated his practice. As to modern practice, the members of this Institute out to be able to furnish full information on church building considering the great activity that has lately prevailed in that branch of practice.

The last topic on which I have to trouble you relates to buildings without any columns internally, in fact large rooms. The most difficult subjects for the architect to treat would seem to be rectangular rooms; perhaps those of moderate size being worse to encounter than larger or smaller ones. Among these I would include great and small halls, lecture-rooms and concert-rooms, and also the majority of dissenting chapels, together with such churches as are not built with a nave and aisles. A rectangular room of considerable size is the commonest form for apartments destined for great assemblies, and is so simple and has become so customary that it will probably never cease to be usual for northern nations, and yet it lies open to nearly all the obstacles which we have decribed as besetting buildings of one or another class. Its flat floor renders it liable to the obstruction of the direct lines of hearing; its straight ends almost preclude any arrangement of auditors on a semicircular or segmental curve. Its flat sides and square angles are very apt to reverberate. Its flat ends coupled with its considerable dimensions expose it to echo. The mass of air in its height, and at the back wall, tends to swallow the speaker's voice, and even its very dimensions allow space for the voice to decay, while it is very possible that its windows or its skylights may afford opportunities for sound to be generated of a disturbing character. I am not prepared to bring forward a single instance that unites all these disadvantages, though Exeter Hall before the alterations might have been instanced as exhibiting a good many of them. I am however better pleased to invite your attention to one or two cases where these obstacles have been all successfully surmounted, and from the consideration of these we shall be able to form some tolerably definite ideas of what a great hall ought to be.

We will first consider the case of the Free Trade Hall at Manchester, the work of Mr. Walters, who has most obligingly furnished full information respecting it. The requirements here, as in most great rooms, embraced fitness for both musical entertainments and public speaking, with accommodation for a very large audience, and good architectural effect. All this has been successfully accomplished. The dimensions of this hall are very considerable; they are, as measured from the contract plans:—the internal width, 104 feet; length, 176 feet; height, 70 feet; thus bearing very nearly the simple arithmetical relations to one another of 2, 3, 5. The plan is a parallelogram with a semicircular sweep at the end opposite the orchestra. The orchestra is partly in a recess, with a roof curved upwards, but advances into the body of the hall. The side walls are low, the ceiling coming down on to them, with a cove of unusual height. The side walls are plain below the gallery, the upper part of them being broken only by engaged pilasters, so that they offer no obstacle to passing undulation, and what reflecting power they exercise will be favourable; but at the remote end where conduction along the walls would commence, and at the semicircular end, the surface is so broken up as to dissipate or destroy the conducted wave of sound. Columns here take the place of pilasters. Deep open recesses used as private boxes are formed, and balconies thrown out on corbels, while the gallery, which at the sides is shallow, becomes here deeper, so as more effectually to check the sound that might reach the back wall and be echoed. The doors of entrance are here too, covered with cloth, and lastly the front of the gallery itself has a section of compound curvature, so that it cannot echo. These precautions, coupled with the curved end of the room, are successful and there is no echo. When full, this hall is very successful either for music or for speaking, but when empty the resonance in it amounts to reverberation.

The good result here, it will be remarked, is mainly due to form and proportions: resonant material is not present in an extraordinary quantity, for the walls are plastered, and so is the ceiling; the floor however has a space underneath it, and there is a large space above the ceiling. I believe there is a good deal of woodwork about the orchestra—the most important part—and there is a large organ there, which I cannot help believing is likely, even when not played upon, to be an auxiliary to sound.

Another example of great fame in the North of England is the Philharmonic Hall in Liverpool. I have hastily visited it, but am not in a position to speak of its good qualities from personal experience, or to lay before you any authorised information except what appeared in the *Builder* at the time the hall was erected. The architect was Mr. Cunningham, and the dimensions given in the *Builder* are:—extreme length, 135 feet; extreme width, 102 feet; extreme height, 68 feet; open part of hall clear of boxes, 106 feet by 68 feet. Calculated accommodation, 2300 persons. The appearance of the hall on entering is most peculiar. Two elliptic arches of vast span extend along the two sides, while smaller ones cross the ends, and by these the very considerable dimensions of the hall between the walls are masked, and it is brought to appear a moderate-sized apartment, with a domed ceiling, and having four recesses opening out of it. These recesses are occupied, one of them by the orchestra, and the other three by two galleries, one above the other, and receding back. The orchestra is the only place where resonant material appears to have been employed. It is built of wood, and contains hollow cavities of considerable size; in all other parts the architect seems to have dreaded resonance as much as echo. The surfaces likely to echo are curtained over and divided with great care; the boxes into which the galleries are divided are hung with draperies, and on nights of concerts the floor is covered with a carpet, and all the seats are cushioned. I have been given to understand that the effect upon music is exactly what might have been expected—namely, that it is heard most distinctly and quite free from reverberation or echo, but that the room affords *no* support or assistance to the voice or instruments. It is perhaps not right to conclude a reference to this building without observing that in arrangement for ingress and egress, for the comfort of its occupants, and so far as one could judge for ventilation, it is one of the best and most liberally planned structures we have.

Coming nearer home we may refer to the very large and very successful music hall in the Surrey Gardens; for authentic information respecting which I am indebted to the architect, Mr. Horace Jones. In this large building enormous audiences have been assembled to hear music and to hear preaching, and in either case they have done so without difficulty. The general form of this building is well known. It is an elongated octagon, or a parallelogram with octagonal ends, and into which the walls of octagonal staircases project. At the end opposite the orchestra and up the two long sides, are built three tiers of galleries with fronts of curved section, and supported on iron columns. The roof over two of these galleries is horizontal, that over the third one inclined, and that over the central space is very similar to the one at Liverpool, both being domed rather like the bottom of a ship. The dimensions of this hall are very considerable, the extreme height and extreme width are within a foot the same, the width is 68 ft. 6 in., the height, 69 ft. 6 in., the length is 153 ft. 6 in., or two and a quarter times the width, another instance of simple proportions. The form is well chosen, and the galleries act extremely well to prevent echo and reverberation, while yet they are not so near together but that they can be well reached in every part by the voice. The principal reliance of the architect for musical beauty of tone was however placed upon the use of resonant materials. The walls are lined with match-boarding on battens, and it was at one time intended to form the ceiling also of wood. The orchestra is constructed of thin well-seasoned planks, and there is a sounding-board over it in a slightly inclined position, the action of which is believed to be very beneficial. This is not only of wood, but it was specially required to be of old materials. That these various precautions have been successful is a matter of notoriety, and in fact they have answered so well that this hall has been pointed out to me by a professional musician as one of the best in London, not only relatively to its vast size, but absolutely.

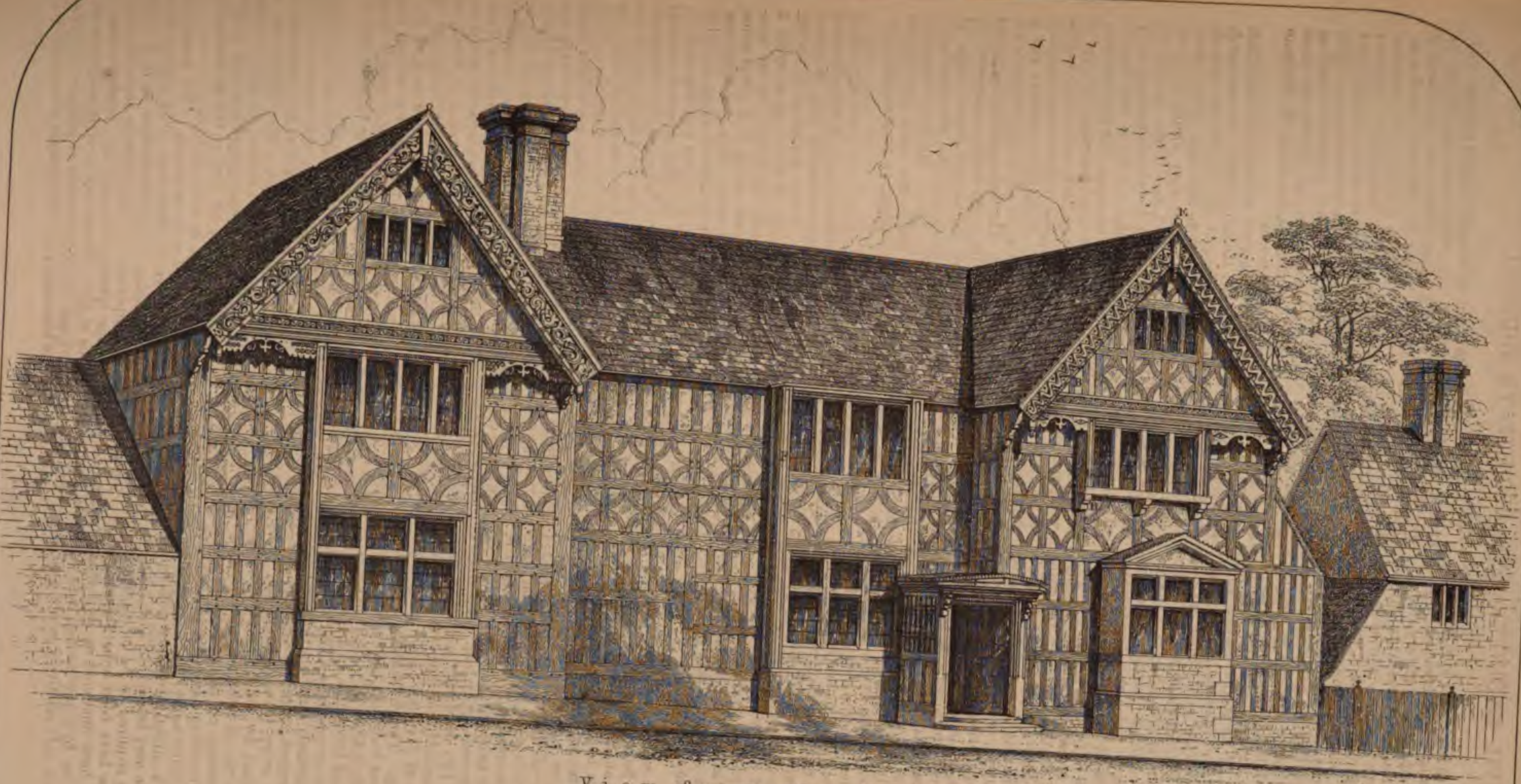
Very many other rooms might be brought forward and analysed, even of those in London alone. To refer to only two others, we will take the ball-room at Buckingham Palace, and St. Martin's Hall. The ball-room was built by Mr. Pennethorne; the dimensions are 110 feet by 60 feet by 45 feet, bearing to one another very nearly the relations of 3, 4, and 8. The angles of the room are rounded, the ceiling slightly roughened with ornament, and brought on to the walls by a cove. The cornice has very little projection, and the lower part of the room is lined with boarding covered with silk. There is a recess at the end opposite the place for the music, broken up with pilasters, &c. so as to dissipate echo. This room is admirable for music.

St. Martin's Hall was mainly designed, so far as its adaptation for acoustic purposes goes, by Mr. Hullah himself. It measured, according to the account published at the time it was opened, 121 ft. 6 in. long, 55 ft. 5 in. wide, and 40 feet high. The dimensions cannot be exactly reduced to any very simple relation, though they are not very far from 2, 3, and 6: the nearest to them are 5, 7, and 15. The height and length however are very exactly proportionate, the height being one-third the length. This room had no recess for orchestra or organ, but the orchestra—probably the most perfect one in London—was built up of wood against one wall. There was a gallery, rather deep across the opposite end, and shallow at the sides, with the front carefully reduced to the minimum of surface. Facing the orchestra was a recess, partly breaking up the end wall. The windows were all high up, and were slightly recessed. The distinguishing feature of this room was its great wooden ceiling, flat in the centre—which occupied about one-half the entire width—and sloped down at the sides to meet the walls. This was panelled, and there were hollow spaces above it, and under the floor. The room when full answered to perfection for music, but it was when partly filled subject to reverberation, owing, no doubt, to its extreme resonance.

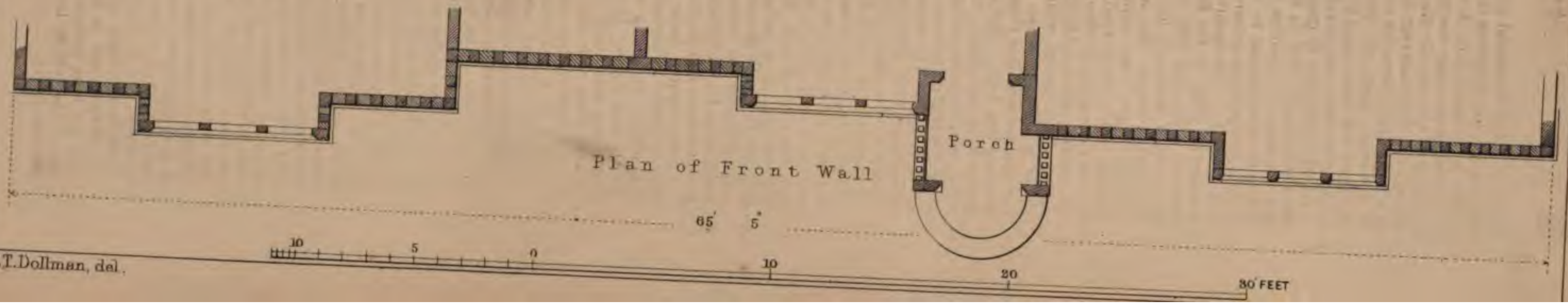
Among the smaller public rooms there are a great number of examples of a class for the acoustic constructions of which I would earnestly bespeak more care than has ordinarily been bestowed upon them. I refer to the small public rooms in suburban villages and country towns, the failure of which is as great a calamity for the community to which they belong as the non-success of the most important structures would be in great cities. These rooms are, perhaps more frequently than not, imperfect, and consequently fail of their end, which is to afford to the inhabitants of the place where they are built a good meeting-place on public occasions. Ordinarily, I think, the small means at disposal lead to the walls being built bare and unbroken, but plastered. The ceiling is often too high for the other dimensions of the room, and if there is any semblance of an open roof, it is so thin and slight as to offer little or no obstacle to reverberation. Very frequently too circumstances render it advantageous to light these places from the roof, and skylights that act as sound-traps are formed; or, if not, at least the walls are left quite devoid of any breaks. It would be desirable in building such a room to pay regard to good proportion, and where practicable to light from side windows. If this is not admissible, perhaps it will be advisable to break the line of the walls by piers and arches of moderate projection, and, above all, to form some description of break, or recess, or cant, or curve in one or both of the end walls, and to make the ceiling drop down at the ends. It would be wise partially to line the walls with wood, or form a wooden ceiling; and if it is necessary to keep the surfaces plain, not to plaster them internally; also to curve or cant off the angles on plan, and to cove or cant the ceiling in section.

In existing rooms that are bad the best remedy must be usually left to the judgment of the architect, as the circumstances of the case will vary, but the most generally useful and inexpensive palliative for reverberation, the usual vice of these small halls, is to hang up curtains in various parts. Matting or carpet on the floor might often be of use, and a sounding-board, or even a sheet of canvas so stretched as to cut off part of the air above and behind the speaker, might often be advantageous.

The subject is now before you, gentlemen. We have considered (1) the general laws of sound, and (2) the mode of influencing sound in a building, namely—reflection, as in a sounding-board, referring especially to the parabolic sounding-board; conduction, as in the speaking-trumpet; and reinforcement by resonance, as in the violin. The subject (3) of impediments next required attention; and we have considered echo, reverberation, obstacles, with the isacoustic curve as a means of escaping them,

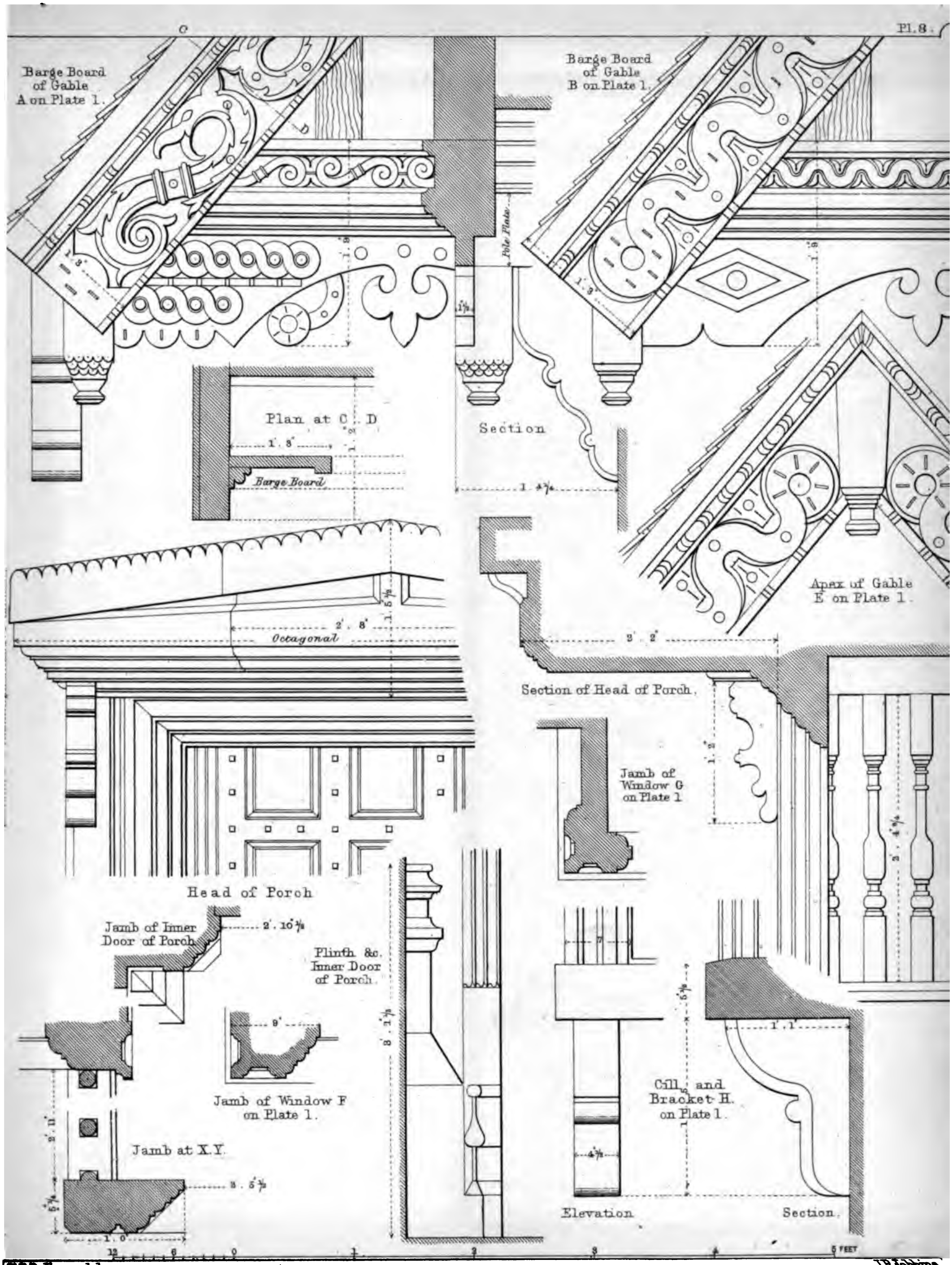


View from the N. E.



Plan of Front Wall

F.T.Dollman, del.


C
Barge Board of Gable A on Plate 1.
D
1' 9"
Barge Board of Gable B on Plate 1.
1' 9"
1' 3"
Pole Plate
1½
Plan at C . D
1' 8"
Barge Board
Section
1' 4½"
Apex of Gable E on Plate 1.
1' 5½"
2' 8"
Octagonal
3' 2"
Section of Head of Porch.
Jamb of Window G on Plate 1
1' 2"
3' 4½
Head of Porch
Jamb of Inner Door of Porch
2' 10⅞
Plinth &c. Inner Door of Porch.
8' 1½"
7
5⅛
9"
Jamb of Window F on Plate 1.
Cill and Bracket H. on Plate 1.
1' 1"
2' 11"
Jamb at X.Y.
3' 5½
5½
1' 0
4½
Elevation
Section.
12 6 0 1 2 3 4 5 FEET

F. T. Dollman, del. J. R. Jobbins

House at Mayfield, Sussex

and bad proportion. Lastly (4) we have referred to the application of these general principles to particular cases, dividing them, according to size and shape, into buildings for direct radiation of sound, or square and round buildings; and buildings for conduction of sound, or oblong buildings. Amongst the former we have noticed theatres ancient and modern, lecture theatres, and courts of justice. Amongst the latter, basilicas and other places with a nave and aisles, and large rooms.

◆

REVIEWS.

An Analysis of Ancient Domestic Architecture in Great Britain. Nos. 1 to 14. By F. T. Dollman and J. R. Jobbins.—London: Joseph Masters.

(*With Engravings.*)

Since the first number of this work appeared (some twelve months since), we have twice taken occasion to call our readers' attention to it; and now, having reached the 14th Number, are enabled, by its greater development, to speak more distinctly of its merits. The subject—the Ancient Domestic Architecture of Great Britain—is one that every day becomes more interesting to architects and archæologists. It is well known that of those early and important structures which were once the hold and home of our sturdy nobles, and the place of safety for their retainers, the relics are fast departing, and that but little remains perfect from which we can gather their architectural beauty and domestic arrangement, and that little is scattered far and wide throughout the island, either in a state of crumbling decay, or changed from the eminent position it once held, to become a barn or stable.

Cathedral and church architecture, as well as castellated, for years past have been well examined, and their antiquities developed with zeal and care; but that which was strictly confined to domestic use has received but little investigation, and a pictorial rather than a professional mode of treatment has been adopted. It is for the latter purpose that the authors of the present work have entered upon their task, and if we may judge from what they have done, there is every reason we should be satisfied with their labours, and receive the present instalment thankfully. At present it illustrates portions of several monastic buildings, hitherto, we believe, unrepresented, with their details shown to accurate measurement. Among these we have the Guesten Hall—once part of the priory—at Worcester, and the Commandery, a building in the same city, so called from the tradition that it once was the habitation of some of the brotherhood of the Knights of St. John of Jerusalem. This statement appears to be doubtful. The refectory of Great Malvern Priory, half-timbered, with its windows having oaken tracery and mullions, is also given,—a most interesting structure, all record of which might have been entirely lost, from the circumstance of its having ceased to exist for more than twenty years; and the venerable remains of Dunfermline Abbey, the last resting-place of the hero of Bannockburn. Of ancient hospitals we have several, with their plans, showing the arrangements of the inmates' dwellings. Most conspicuous among these is Holy Cross, near Winchester, shown in detail on several plates; and Ford's Hospital at Coventry. If such structures are not to be copied in our days, they are at least highly suggestive. The palace of Linlithgow—the birthplace of the ill-fated Scottish queen—as it at present stands, is also represented in ten plates; it has many remarkable features deserving of notice, especially the window-heads and fireplace, and is accompanied by the interesting memoir which we noticed recently. Here are also some choice examples of windows from Oakham Castle and Battle Abbey, and many hooded and other fireplaces of noteworthy design. An assemblage of ancient ironwork, embracing knockers, closing rings, latches, a sliding candlestick, and several keys with elaborately ornamented bows, occupy several plates; others are devoted to some strikingly picturesque half-timbered dwellings, of some centuries' standing, from Kent and Sussex, with quaint gables, pendants, and barge-boards. We think, from our enumeration of the published illustrations in this analysis, it will be seen that as far as the work has gone it is one that will command a prominent place in every professional library, if finished with the same care and judgment as at present bestowed upon it by the painstaking authors.

It was our intention to have dwelt at greater length upon the execution of the plates, and the clearness and conciseness of the accompanying descriptions; but as a specimen of both would be preferable to any eulogy of our own, we have obtained permission to insert an example of the plates. The subject is the view and plan of frontage and details of an ancient timber-house at Mayfield, in Sussex; these plates accompany the following particulars:—

> "The village of Mayfield—or, as anciently spelt, Mayghfeld or Maghfeld—has for its boundaries, Frant on the north, Heathfield on the south, Burwash on the east, and Rotherfield and Buxted on the west. It is situated on the summit of a hill, whence the view is extensive, and in some parts richly wooded; and in general has the local characteristics peculiar to Kent and Sussex. The village has one principal street or road traversing it from east to west, and on the south side stands the house of which the accompanying engraving is an illustration. No especial historical interest is attached to the house, which is merely an ordinary residence; but the picturesque or quaint expression which it possesses is its chief distinguishing characteristic. The chief features in the front elevation consist of two wings, projecting slightly in front of the centre portion of the house. The two barge-boards in the gables differ in their design, the ornaments in one of them bearing some resemblance to examples at Abbeville, in France. The gable wall projects about 18 inches from the wall below, the bay window also projecting the same from the wall. The ornamental boarding which connects the feet of the gables with the bay window gives considerable character to them in its mode of treatment. Between the wings there is no projection, except one bay window, and the entrance porch. The timbers forming the framing on the upper floor are curved similarly to many of the examples in Shropshire and Cheshire; but on the ground floor the framing is plain, the *tout ensemble* being quaint and picturesque. The ground floor bay window in the western wing is modern, as is also the glazing of the windows generally. The date 1575 appears in each of the gables. The interior of the house has been modernised throughout, with the exception of two fire-dogs, apparently of French design and manufacture, in the entrance hall. The view given is taken from the north-east."

Observations on the Niagara Railway Suspension Bridge. By Peter W. Barlow, C.E., F.R.S.—London: Weale. 1860. 8vo. 40 pp.

Are tubular bridges costly blunders? This is in effect the question raised by Mr. Barlow's pamphlet. On a recent visit to America he has inspected the railway suspension bridge which crosses the Niagara river near its Falls, and has satisfied himself that the structure is sufficient for its purposes, and that the best mode of constructing railway bridges of large span is by ordinary suspension chains supporting horizontal girders.

In order to make clear the tenor of the few remarks which we have to offer upon this pamphlet, we may at the outset state our assent to the conclusion of Mr. Barlow, that tubular bridges are not the best forms of railway structures of large span, though we most materially differ from him as to the accuracy of his comparison of the various kinds of bridges. In a former volume of this Journal, during the progress of the experiments which were conducted for the purpose of determining the form and dimensions of the Menai Tubular Bridge, we published a series of investigations showing that a sacrifice of economy of materials was occasioned by the omission of the suspension chains which it was at one time proposed to attach to that bridge; and, if our recollection be accurate, Mr. Hodgkinson—not the least eminent of those who took part in conducting the experiments in question—publicly expressed his regret that the auxiliary suspension chains were abandoned. More recently, in the numbers of this Journal for November and December 1860, appeared two papers —which we take leave to regard as very valuable contributions to the science of engineering—showing the great economy which results from combining suspension chains with girders. Whether the combination there considered be the most economical that can be devised,—whether greater economy would not result from a suspension of girders by tension bars radiating from the points of suspension, or some other mode of suspension, we do not now decide. But from these two papers it is at least obvious, that in comparing suspended and unsuspended girders the former have greatly the advantage in point of economy. And this conclusion is supported by a very high authority on this subject, Prof. Macquorn Rankine, in two letters in our numbers of December and January last. In the latter of these letters Prof. Rankine arrives at the conclusion that a suspended girder need have only about *one-seventh* of the strength of an unsuspended girder of the same span and required to sustain the same travelling load.

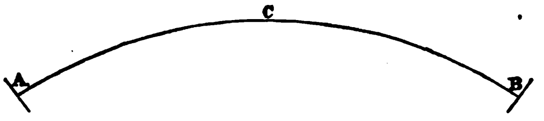
It is notorious that tubular bridges, of which that over Menai Straits and the Victoria Bridge in Canada are the most conspicuous examples, are enormously expensive. It is notorious that the cost of those two bridges has been ruinous to the companies which constructed them. There is not much difficulty in arriving at the reasons of this result. In the first place, tubular bridges are extremely complicated structures, consisting of a vast number of parts which have to be fitted together with extreme accuracy. In order to prevent the top of the tube from bulging or "buckling" from the compression to which it is subject, the expedient of a cellular structure of that part of the tube is adopted, and it consists of numerous cells formed of iron plates, with an immense number of joints and rivets. Now all this difficulty of counteracting the tendency to distortion is avoided in suspension bridges, for in them the strains, being tensile instead of compressive, tend to counteract instead of tending to cause distortion. Again, in suspension chains the material is so disposed as to more directly sustain the travelling load than is the case in girders or tubular bridges. In the latter the source of strength is rigidity,—that is, the moment of the elastic forces of tension and compression; and this moment of forces is limited by the depth of the structure; so that, to speak in popular language, the elastic forces can never have a greater leverage than the distance between the top and bottom of the tube. But in suspension bridges the similar leverage is far greater. For the equilibrium of the half-span, the moment of the weight upon it about the abutment is equal to the moment about the same axis of the tension, which acts at the summit of the chain. But it is obvious that the tension at the lofty summit of a suspension tower has far greater leverage about the abutment than the compressive forces of a tube of far less altitude would have about the same axis.

It seems quite certain from Mr. Barlow's observations on the Niagara Suspension Bridge that, notwithstanding certain defects in its construction, it is in a great degree successful. The span of that bridge is 821 feet, exceeding, as it is stated, by 361 feet the longest girder yet constructed. "It is composed of wire cables, to which longitudinal stiffness is given by timber trussing, and contains between the towers 600 tons of wood, and 400 tons of iron. The Britannia Bridge, the next largest railway span in existence, has 3000 tons in each span of 460 feet." The Niagara Bridge has been in use for five years and a half, and is subject to a heavy goods traffic. During the passage of an ordinary passenger-train, estimated to weigh 80 tons, Mr. Barlow observed the deflection to be ·41 of a foot, of which he estimated the deflection due to actual elongation of the cable to be ·182 of a foot. The pamphlet before us gives several interesting particulars respecting the bridge, and an estimate of its merits and defects, which seems to us to be in general judicious and accurate.

But at this point our accordance with Mr. Barlow's views ceases. His subsequent investigations of "the mechanism of bridge construction," in which he estimates quantitatively the comparative strength of different kinds of railway bridges, are to our apprehension erroneous from beginning to end. He says,—

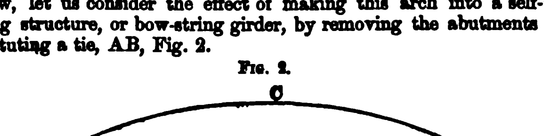
> "My object is now to endeavour to explain why these differences are consistent with understood mechanical laws, and the peculiar properties of the material employed.

Fig. 1.



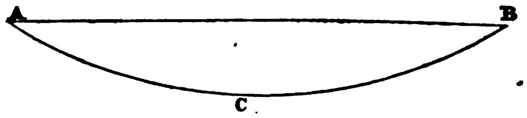
> Let ACB, Fig. 1, represent an arch supported on abutments, A and B; and let the deflection produced by a given weight, loaded equally, be represented by unity.
>
> Now, let us consider the effect of making this arch into a self-supporting structure, or bow-string girder, by removing the abutments and substituting a tie, AB, Fig. 2.

Fig. 2.



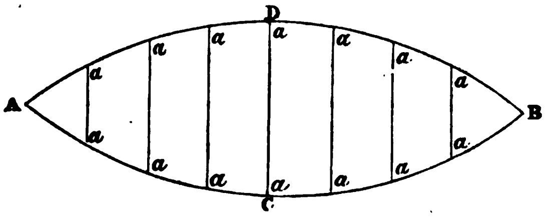
> Assuming the same weight, W, to be placed equally all over, the deflection will be 2, the points A and B being no longer rigid, because the tie AB will extend as much as the arch ACB will compress. Therefore, to produce the same rigidity in a bow-string girder, four times the metal is required as compared with an arch.
>
> The same result arises in a cable ACB, suspended from two fixed points. A and B, Fig. 3.

Fig. 3.



> If the back chains are removed, and a compression-tube, A B, substituted, the metal is doubled, and you have a structure of only half the rigidity. The Chepstow Bridge on the South Wales Railway is an example of this arrangement.
>
> The mechanical combination in the Saltash Bridge is represented by substituting the arch ADB for the tie AB, Fig. 4, forming a combination of a suspension chain and an arch.

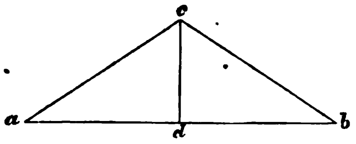
Fig. 4.



> The arch ADC will not perform the duty of compression unless it is connected with the chain by the ties, *aa*, *aa*. When thus connected, both the cables and the arch assist in supporting the weight of the load.
>
> The points A and B now become fixed points, and as both the arch and the chains assist in supporting the weight, the deflection will only be half that of the simple suspension cable, with double the weight of metal.
>
> It therefore appears—1st. To convert an arch supported on two fixed abutments into a bow-strung girder, four times the metal is required to support the same weight with the same deflection.
>
> 2nd. To convert a cable suspended from two fixed points into a Chepstow girder, four times the metal is also required to support the same weight with the same deflection.
>
> 3rd. To convert the same cable into a Saltash combination (which consists of a bow-string and Chepstow girder combined, so that the horizontal tie in one case neutralises the compression-tube in the other, by which they are both avoided), the deflection is reduced one-half, with double the weight of material, or the same weight of metal will produce the same deflection with the same load, as in the case of the simple arch or cable. But this is obtained at the expense of double the depth; and if the arch or suspension-cable was of the same depth as the Saltash, only one-quarter of the metal would produce the same stiffness."

Every one of these conclusions appear to us to be incorrect. Take first the comparison of the structures, represented by Figs. 1 and 2. The author says that in the second case the deflection will be twice as great as in the first, "because the tie AB will extend as much as the arch ACB will compress." This seems to assume that the arch ACB will suffer compression only, which is certainly not the case. The arch, if loaded only at its summit, will be subject to transverse strains which will alter its radius of curvature at every point; the total amount of displacement of any part of the structure due to that alteration of curvature, could be estimated only by a very difficult investigation, and the result probably would be very complicated. But of none of these difficulties does Mr. Barlow take the slightest notice.

Let us however take a case in which the difficulty arising from the variation of curvature is avoided. Even there Mr. Barlow's conclusion will be found to be not near the truth.



Suppose instead of the arch ACB we have two straight bars *ac*, *bc*, connected by a joint at *c*, and resting on abutments *a* and *b*, and there connected by a tie *ab*. Mr. Barlow's conclusion, if accurate, ought to apply to this structure as well as to the arch, because his proposition does not take the curvature or rigidity of the arch into account. Therefore, in this structure also the deflection ought to be twice as great when points *a* and *b* are connected by a tie-rod as when they are immovably fixed. But is it not obvious that the relative amounts of compression and extension must depend (*inter alia*) on the relative compressibility of the oblique bars and the tie? For instance, the latter might be so thick and of metal so inextensible, and the former so weak and of material so compressible, that the weight compressed the latter greatly, and extended the former scarcely at all: in this case the deflection would be the same as if, instead of tie-rods, the points a and b were fixed. To put this to the test of simple analysis, let $ac = r$, $cd = x$, $ad = y$. Suppose the variations of these quantities after deflection to be δr, δx, δy, respectively; then since $x^2 + y^2 = r^2$, we have $x\delta x + y\delta y = r\delta r$, nearly. If however the distance from a to b be invariable, as where the points a and b are immovable, δy is zero, and we have $x\delta x = r\delta r$. Therefore the deflection δx is in the former case $\frac{r\delta r - y\delta y}{x}$, and in the latter case $\frac{r\delta r}{x}$. Therefore $\frac{y\delta y}{x}$ is the difference of the deflections in the two cases. Also it may be easily shown that the tension of the tie due to a weight 2W at the vertex is $W\frac{y}{x}$, and if μ be the compression of a unit of the length of the tie by a unit of tension $\delta y = \mu W \frac{y^2}{x}$. Consequently $\mu W \frac{y^3}{x^2}$ is the difference of deflection in the cases in question. So that instead of the deflection being simply doubled, as Mr. Barlow states, it depends on the cube of the span and the square of the altitude of the structure.

Similar objections apply to each of the other conclusions above quoted. We have no hesitation in affirming that they ignore all the real difficulties of the subjects to which they relate, and are wholly incorrect.

In his theoretical comparison of the deflections of suspended and unsuspended girders our author is equally unfortunate. He says:—

"It has been assumed that the degree of longitudinal strength or girder-power, to cure the wave from railway traffic, would require to be so great that the girder would carry the traffic without the cable, and thus the failure of the Niagara Bridge was predicted; but a brief consideration of the subject satisfied me that such an assumption was far from the truth.

The formula $\frac{l^3 w}{bd^3\delta}$ = a constant quantity, δ denoting the deflection, and l, b, d, the length, breadth, and depth of a beam, is fully established; or in other words, the deflection of a beam with a given weight diminishing as the cube of the length. If the beam AB, Fig. 5, be divided into two beams by being supported at C, the two half beams AC and BC, will deflect one-eighth of the amount of the entire beam AB, with the same weight. Let us assume this to be a girder attached to a chain and a load placed at D, the effect will be to distort it into the shape shown in Fig. 6.

Fig. 5.

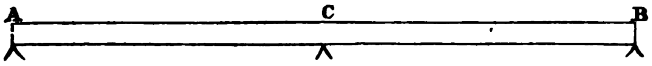
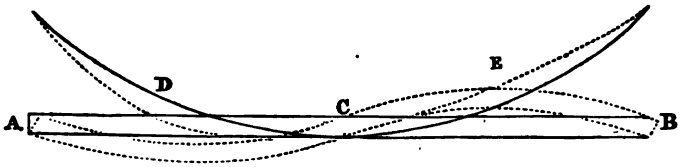


Fig. 6.



The deflection by the weight at D will cause a corresponding elevation at the point E, and the girder will assume the shape represented by dotted lines in the figure, to produce which a force equal to double that for a given deflection on half the beam is required, from which it is evident that the wave produced by a given weight at D, will only amount to one-sixteenth of the deflection the same weight will produce on the entire beam resting on its two ends."

It is here assumed that the deflection of the girder ACB will be the same as if C were a fixed point, and that that point in the centre of the suspension supports the beam in the same way as the fixed point C in Fig. 5. But, in truth, the resistance of the point C is not nearly the same in the two cases. A characteristic of simple suspension chains is their mobility. In a railway bridge, properly constructed, the deflections would always be so small that a force inconsiderably small, compared with the actual deflecting load, would suffice to maintain any such small deflection at the centre of the chain *alone;* that is, unassisted by the girder. Consequently, so far from the point C offering the same resistance to depression as if it were a fixed point, it would in practical cases offer a resistance almost inappreciable; and therefore, instead of the deflection of the beam AB being reduced to one-sixteenth of what it would be if not connected with the point C, it would be almost precisely the same as if the beam were not connected with that point. It may be added, that Mr. Barlow's conclusion that the deflection is reduced to one-sixteenth, is incorrect, even if we admit his assumption that C is a fixed point. As, however, that assumption is erroneous, it is not necessary to demonstrate the error founded on it.

Mr. Barlow has curiously enough selected, as an instance of the efficiency of catenary chains to reduce the deflection of girders, the one instance in which such chains are ineffective. The chain connected with the girder at its middle point only would be simply useless; it is only where the connection is at numerous points that the suspension chain is a valuable auxiliary. In that case the chain, if deflected at one point, tends to rise at others. If those other points be connected by inextensible vertical rods with the girder, the tendency in question is resisted, and the upward *pull* of the vertical rods is the real cause of the efficiency of the chain to resist the deflection of the girder. For the reasons just mentioned, the elevation of the girder at E, and the contrary flexure referred to by the author, will occur only when the girder is attached to the chain at several points. The statical effect of that contrary flexure of the beam cannot however be ascertained by any "brief consideration;" and, after perusing the recent papers in this Journal on Suspension Girder Bridges, the reader will probably be of opinion that the subject cannot be satisfactorily disposed of without recourse to the differential calculus.

The question of the comparative economy of different kinds of railway structures is one of the very highest importance to engineers, and it would therefore have been unjust to our readers to pass over in silence what appeared to us erroneous in the published theories on the subject. We most readily acknowledge the merit due to Mr. Barlow for his raising the question as he has done, for his very useful experiments on model suspended girders mentioned in this pamphlet, and for his careful examination of the Niagara Bridge. But while acknowledging these merits, we deem ourselves free to dissent from his theories, and certainly consider that it would be most prejudicial to the progress of engineering if crude doctrines such as those here noticed were allowed to take the place of matured and demonstrable conclusions. It may be added that Mr. Barlow seems to place entire reliance on his own views, as he proposes to connect Liverpool and Birkenhead by an enormous suspension girder bridge, of the principal parts of which he assigns what he deems to be the proper dimensions. The span of this bridge is proposed to be 3000 feet, and its cost is estimated by him at £1,000,000.

An Essay on the Thermo-Dynamics of Elastic Fluids.
By Joseph Gill.—London: John Weale. 1860-1.

It is but a short time since we introduced to our readers the recent discoveries of Mr. Wye Williams respecting the properties of heat, and the relation it bears to water and steam: relations which were however more of a chemical and physical character, viewed in connection with the various phenomena of heat in its different conditions, than of a nature purely mechanical. This latter consideration forms the sole subject of the book before us, which, as its title imports, treats of the chemical action of heat in the production of *mechanical work* from the development of expansion of elastic fluids. In other words, Mr. Williams tells us what heat *is* as far as it is related to water and steam; while the author of the present essay informs us what heat *does*. This book cannot fail therefore to be of especial interest, inasmuch as —although a good deal has been written on the cause and nature of heat—little or nothing deserving acceptance has been advanced respecting the *mechanical theory of heat.* It was principally through Messrs. Joule and Mayer that we were first made familiar with the conclusions that heat and mechanical work are mutually and reciprocally convertible; indeed, that they bear a definite relation to each other—namely, that the mechanical work developed from a unit of heat (that quantity of heat which is necessary to raise the temperature of 1 lb. of water one degree of the Fahrenheit scale) is exactly equivalent to the work expended in raising a load of 772 lb. one foot high, or, what is the same, in raising one pound 772 feet high. How far this conclusion is correct, and from what direction we have to view it, has been very clearly pointed out by the author. The principles on which the above deductions are based, as Mr. Gill observes, no doubt appear to be in accord with the general law of the conservation of force, which maintains an unchangeability of force in the universe (as far as quantity is concerned) as well as an unchangeability in the quantity of matter,—which asserts that there is no loss nor deduction, no production nor addition, but that in every case we meet only with transfer, change of form, condition, or direction. It is therefore the question whether this law would be equally applicable to heat or caloric as the work-producing medium. The fact that steam, after having passed through the steam-engine and developed a certain quantity of mechanical work, still contains (assuming it suffered no diminution of heat by radiation) the same quantity of heat, must at once deter the inquirer from forming a definite conclusion as to such an analogy, were the production of mechanical work by the steam not accompanied by a change in the condition of heat owned by the elastic fluid. It is therefore to this change that we must look for the solution of the problem. In considering this question, Mr. Gill maintains that it is necessary to distinguish between statical force and dynamical force of elastic fluids, in order to form a clear conception of the thermo-dynamical phenomena of machines. It is the pressure or tension of a constant volume of steam—like that confined in a boiler—which is here meant by the author to convey the idea of a statical force of this elastic fluid. This force, like other statical forces, is characterised by an immobility of the energy exerted, and is therefore a question of equilibrium. The heat or temperature in this instance is sensible, whilst the co-relative mechanical equivalent is latent or undeveloped. On the other hand, dynamical force of elastic fluids is exhibited by energy in motion, as is observed in the phenomena of expansion of a definite volume of steam. In the latter case sensible heat is converted into latent heat, and the issue is sensible work, which is invariably accompanied by a fall in temperature.

After having dwelt at some length upon the nature of heat, its source as a mechanical agent, its two states, and the transformation from one to the other, viewed in relation with their mechanical equivalents, the author proceeds to consider the analogy between the thermo-dynamic phenomena of the steam-engine and those of the air-engine. The general conclusions arrived at in these inquiries may be enumerated as follows:—

"1. I assume that heat, in its general signification as used in treating of thermo-dynamics, is molecular motion of ponderable matter.

2. That the conversion of sensible heat into latent heat, in the development of vapours and the expansion of elastic fluids, is either the approximate cause of dynamical force mechanical work; or that such conversion and mechanical work are co-existent and inseparable consequences of some common cause.

3. That the energy or work-producing principle of heat in elastic fluids is proportional to the amount of sensible heat they contain,—their latent heat being indicative of work already performed, and incapable of performing more work *directly* in an engine. That consequently there is not a definite equivalence of heat and mechanical work, as the proportion varies with the *condition* of the heat in the elastic medium; and that Carnot's hypothesis, which attributes the dynamical force of elastic fluids to their expansion with fall of temperature but without loss of heat, seems so far to agree with the actual phenomena.

4. That as elastic fluids may receive heat indefinitely, and any heat communicated to them under constant volume exists in them as sensible heat, the higher the temperature the greater the quantity of mechanical work produced by a given quantity of thermometric heat:—that therefore instead of an equivalence of heat and mechanical work, we should assume an equivalence of calorific energy and mechanical work.

5. That the specific heat of gases and dry vapours increases as their density decreases, while in saturated vapours the specific heat is a constant quantity; consequently, while saturated vapour in expanding performs work merely by change in the quality or condition of the heat in possession, progressing in a constant ratio to the work done, gases and dry vapours, to perform work in proportion, require a quantity of heat to be communicated to them while expanding equal to their increase of capacity for heat under the circumstances: this heat must be communicated as sensible heat, and becomes latent in the expanding fluid; the amount of heat so converted being the measure of the work performed.

6. That as nothing but the equivalent and correlative dynamical force can re-convert this latent heat into sensible, the heat representing the mechanical work performed by an air or steam engine cannot be *directly* recovered, and (excepting in cases of a repetition of the process at lower temperature, as in Du Trembley's plan) we must get rid of it from the engine at once. I may add,

7. That in elastic fluids an equalisation of temperature with contiguous substances takes place at a rate depending on the tension of the heat irrespective of its condition of latent or sensible. Thus the heat of vapour or of hot air would equally be absorbed by a mass of wire-gauze of lower temperature; the former as latent heat which assumes the sensible condition in entering the metal, but at a lower tension which cannot re-convert into vapour the water of condensation under constant circumstances; the latter as sensible heat which might be given back to the air, theoretically without loss."

The application of the theory of transformation of heat to thermo-dynamical engines is next treated of. The relation between the steam consumed and the work performed is here questioned with respect to the ideas entertained by Seguin of the advantages to be derived from working steam expansively. While on this subject the author compares the efficiency of the steam-engine and various other engines depending in their action on the conversion of heat into mechanical work. To the latter class belongs the air-engine, the advantages of which—realised in its application on virtue of the extensive range of temperature this engine may be made to work with—were pointed out several years ago by Prof. Thomson.

With respect to the economy of fuel to be effected by the use of dry or superheated steam, Mr. Gill says:—

"From the result of original experiment, corroborated by recent practical experience in several marine engines, I am convinced of the advantage of dry or super-heated steam as far as economy of fuel is concerned, provided the slides and pistons keep in good working order. We have seen that, under constant volume, any quantity of heat communicated to steam out of contact with water will continue to exist in it as a sensible heat, which in this case appears to be the true cause of work, or source of mechanical effect. We have also assumed that the specific heat of dry steam, like a gas, decreases as its density increases, and hence another source of economy from its use as a dynamical agent. Moreover the well-known loss of heat from internal evaporation and condensation in the cylinder is also avoided with dry steam. The heat recovered from the flues or uptake in superheating systems, and the increased volume of the steam from increase of temperature, are also additional sources of economy of fuel, but of minor importance. On the whole we perceive that superheated steam offers so many theoretical points of advantage, that every effort should be made to obviate or correct the serious practical and mechanical difficulties which the method of superheating involves."

After having stated his opinion of the advantages of the use of superheated steam, and the disadvantages which have in many respects still opposed its general introduction, and hinted how such disadvantages may be obviated, the author adverts to the danger of boiler explosions which attend the method of superheating the steam. The views generally entertained of such accidents are, that the temperature of steam may be considerably increased by imparting to it additional heat after its disengagement from the water, without increasing the pressure to a proportionate degree,—in fact that steam under these circumstances assumes the nature of ordinary gases. It is therefore supposed that steam, when it has been overcharged with a considerable and excessive amount of heat, and happens to come by any sudden disturbance or priming of the water in the boiler in contact with the latter, it unites with it, forms spontaneously a superabundant quantity of steam, which, not finding vent in time proportionate to its generation either through the safety valve or the steam engine, and being of a pressure greater than that which can be resisted by the boiler, acts with such a momentum that a violent explosion is the consequence. The author however dissents from this view, inasmuch as the heat necessary to convert the water in the boiler to a certain volume of low pressure steam would equal the heat which is necessary to surcharge several such volumes of steam 400 or 500 degrees. From this it would follow (if the supposition of the abstraction of heat from the superheated steam for the spontaneous formation of new steam were true) that the volume of superheated steam would contract to a far greater extent than the increase of volume resulting from spontaneous formation of new steam. The consequence resulting from such operation would therefore be a pressure below instead of above the normal pressure.

In conclusion, the author does not omit to notice the failures which up to the present time have rendered a more general introduction of caloric and regenerative engines impracticable, and suggests the application of moist air as a motive fluid. Of the practicability of the latter he offers a lengthy explanation, which will especially interest the reader in perusing his book.

EXAMINATIONS FOR THE ARCHITECTURAL PROFESSION.

We have from time to time made our readers acquainted with the progress of this subject, and are now able to announce that a further step has been taken. The council of the Royal Institute of British Architects, who originally brought the subject before their members, having towards the end of last year elicited an expression of opinion from the general body of fellows that a voluntary architectural examination was desirable, proceeded to invite the other architectural societies throughout England to express an opinion on the subject. Accordingly, in reply, several series of resolutions, differing pretty widely in their scope, were forwarded by the various societies as the results of their deliberations, and were read to the members of the Institute at a recent meeting.

That meeting was held specially with a view to discuss the subject, and ended by affirming that, as the decision had been come to that an examination was desirable, the Institute takes upon itself the labour of constituting one. The idea of a diploma seems to have been almost universally condemned, and the intention of establishing a sort of standard of knowledge, with a view to promoting the better education of the rising architect, is the only object *just now* aimed at. It was further decided to open this examination to all British subjects making a satisfactory declaration of their intention to practise as architects, and that the council shall, with the assistance of a committee, elaborate a scheme to be discussed at a future day.

The most important points yet settled are—that an examination will be instituted, and that its aim is to be educational only. We shall look with interest for the details of the scheme, and of the proposed certificate to those who may pass. Upon these points a good deal of discussion is anticipated.

◆

A NEW PROCESS OF OPEN COKING.*

By Samuel H. Blackwell, of Dudley.

All coals divide themselves into one of two classes, bituminous and anthracitic. The first class is again subdivided into caking and non-caking coal. It is only these two varieties of bituminous coal which are ever submitted to the process of coking; in anthracitic coal there is not a sufficient quantity of gaseous matter present to render the process of coking necessary or practicable.

The means employed for coking bituminous coal depend upon whether the coal to be coked is of a caking or non-caking quality. For coking the caking coal ovens are almost always used. From two to four tons are usually coked at each operation. In the best ovens the great objects aimed at are:—first, as high a temperature as possible, by heating the air required for the combustion of the gases previous to its admission into the oven; secondly, the utilisation of the heat produced by carrying the ignited gases under and round the oven before allowing them to pass off; and thirdly, the admission of the smallest quantity of air necessary for combustion at such a point in the oven as will best prevent any cutting or wasting action upon the coal, either during the process of coking or afterwards, before the charge is drawn.

In South Staffordshire and elsewhere, where the coal is of a non-caking quality, open coke fires only have hitherto been used. These consist in their simplest form of a brick chimney or open flue, abut 4½ to 5 feet high and about 2 feet diameter inside at the base and 18 inches at the top, around which the coal to be coked is carefully arranged, air holes being left in the sides of the chimney. The largest and longest pieces of coal are first piled up against the central chimney; against and upon these other large coals are piled until they reach up as high as the chimney itself, and outside these again other coals of smaller size, the outside of the coke heap being carefully rounded off with smaller coal or cobbles. The quantity of coal coked in open circular coke heaps varies from 10 to 30 tons, according to the quality of the coal and the purpose for which the coke is required. When the heap has been thoroughly rounded off, fine coke-dust is mixed with water into a sort of paste, called "blacking," and with this the whole of the heap is carefully covered excepting about 6 inches height at the bottom, which is left open to admit the necessary amount of air for the combustion of the coal. Fire is then applied to the top of the coke heap close to the chimney; it gradually spreads along the line of draught down the chimney, and when it has attained sufficient strength it bursts out at the foot of the heap. As soon as this is the case, and the lowest portion of the heap is sufficiently coked, the bottom of the heap is gradually covered up with dry coke-dust, so as to exclude the air, and prevent the waste which would otherwise occur. As the fire extends upwards the blacking gradually burns off higher and higher; and as this takes place the fresh covering of dry coke-dust is also extended upwards, but so as always to leave space enough between it and the unburnt portion of the blacking for allowing a sufficient quantity of air to enter to complete the coking process, and avoid smothering the coal. When the blacking has burnt off entirely the covering of new coke-dust is made complete to prevent any further admission of air; the whole is damped down and allowed to cool gradually, and water is then poured into the fire to complete the cooling, and to act to some extent as a desulpherising agent, aqueous vapour always acting more or less in that way when in contact with red-hot coke. The process is now complete, and the coke is drawn for use. Besides the round coke heap with one main central chimney or flue, long heaps with one or more chimneys or flues are frequently used; but in every modification of size or shape the same general principles are invariably carried out. The air to support combustion always enters the fire from the surrounding atmosphere, and the products of combustion in the shape of dense masses of smoke or flame pass off from the chimneys; there is also always a greater or less extent of surface of burning coal exposed to the air. In fact, no one of the various processes connected with the manufacture of iron has so great an effect in destroying the general appearance of an iron-making district and filling the atmosphere with smoke as the open coke hearths; and hitherto it has seemed as if it were precisely in this department of the manufacture that it is the least possible to get rid of this nuisance.

In consequence of having largely employed the pitch produced in the distillation of coal tar for the purpose of giving a binding or caking property to the non-caking small coal or slack of the South Staffordshire district, the writer's attention was directed to the possibility of collecting the products of combustion from the open coke heaps. It is well known that all bituminous coals give off in combustion gaseous products, which yield by condensation certain quantities of gas tar and ammoniacal liquor. The quantities of both vary greatly according to the character of the coals themselves, the more or less perfect condensation of the gases, and the temperature at which the coking process is effected. As a general rule Cannel coals yield the largest percentage; and with all coals, the lower the temperature during the distilling or coking process, the greater is the quantity of gas tar obtained. A few simple experiments showed the possibility of collecting some of these products from the open coke heaps. A pipe was inserted into the coke heap near the top of the central flue, and its other end brought down into a bucket filled with water. A portion of the products of combustion was at once condensed, and ammoniacal liquor and some small quantity of gas tar were obtained. This experiment was followed by more careful ones, which led at last to the process of Open Coking now to be described.

In the new arrangement a central chimney or flue is built precisely in the ordinary way for coke heaps. From the bottom of the chimney a cast-iron bend leads off into a pipe laid about 2 feet below the surface of the ground, which delivers into the main, running at right angles to it and passing to the condensers; the condensers communicate at one side with the receiver, and at the other with the stack. Two dampers are provided for each coke heap, one to close the top of the chimney, and the other to close the bend pipe at the bottom. The coals are arranged round the central chimney exactly as in the ordinary coke heaps, and the heap when rounded off on the outside is covered with the ordinary blacking. This blacking however is spread over the entire heap, and no margin left open for draught at the bottom, as is generally the case in the open coke heaps. Fire is now set to the heap at the top; the top of the chimney is closed by its damper, thus shutting off all direct communication between the open air and the chimney; and the damper closing the bend pipe is lifted up, so as to open a free passage into the pipe which communicates with the main and so to the condensers. If the stack connected with the condensers be powerful enough, sufficient air for the combustion of the coal passes through the coating of blacking to the fire; and as combustion goes on in the heap, the gaseous products given off pass into the central chimney, and thence through the bend pipe and main to the condensers. The main is laid with a slight fall towards the condensers, and kept cool by a current of water passing over its entire surface; and the condensers are also cooled by jets of water allowed to flow over them.

---

* From a paper read at the Institution of Mechanical Engineers.

As soon as the fire is at all advanced, gas tar and ammoniacal liquor begin to flow from the lower end of the main into the receiver. The gases after leaving the main pass into the first large condenser and thence into the second, in both of which condensation goes on; and finally the uncondensed portions of gas pass off into the stack. From both the condensers ammoniacal liquor and gas tar are collected and flow into the receiver. Condensation in these condensers is facilitated by a series of iron plates placed in them, against which the uncondensed gases strike as they pass onwards towards the stack. These means of condensation are very imperfect, and are capable of great improvement, but were adopted as being at the time the most convenient. If the draught of the stack be sufficiently powerful, and if the bend pipes and main are of sufficient area, combustion goes on somewhat more rapidly than in the ordinary coke fire. No smoke properly so called is ever visible, except from the top of the stack. No open burning surface is ever allowed to exist, and consequently even at night no flame whatever is visible; the blacking never burns off entirely, but as it dries and becomes partially consumed on its under surface where resting upon the hot coke, it is renewed from time to time, thus preventing any unnecessary waste in the coke heap, and consequently the yield of coke is larger than in the ordinary method of open coking. No greater care is required in attending to the fires than in the ordinary coking, and thus no extra expense is incurred.

In the arrangement of the pipes and main three points require attention. First, the area of the pipes and main must be sufficient for the free passage of the products of combustion. The cast-iron bends and the pipes leading into the mains hitherto employed are 12 inches diameter from the chimney to the main, and the main itself is 18 inches diameter; but the first should be at least 15 inches and the latter 24 inches diameter. Second, the amount of fall, both in the pipes leading into the main and also in the main itself, must be sufficient to carry off the condensed products as rapidly as they are formed. If this be not the case the result is, that the gases being partially condensed the moment they leave the chimney of the coke heap, gas tar is produced, which, if it does not pass off at once, is again distilled by the great heat of the pipe where it passes underneath the coke fire, and solid pitch is produced, which gradually accumulates and chokes up the pipe. It is therefore desirable to have manholes or lids to these pipes, so that they may be examined and cleared out from time to time. Third, the cooling of the main by a stream of water flowing over it. To effect this the main is laid in an open brick culvert, which is kept filled with a current of water. It is desirable to have manholes on the main also, so as to be able to examine it at any time; but if properly cooled by water, and laid with sufficient fall, it will keep clear without any attention. The water reduces the temperature below that at which re-distillation of the liquid products of condensation can take place, and consequently no solid products can be formed to block up the main itself; but this depends altogether upon the main being kept properly cooled.

The quantity of liquid products obtainable by the condensation of the gaseous products of coking is very remarkable. It is known that in the process of coking in closed retorts the gaseous products given off produce on an average, by their partial condensation alone, 20 gallons of gas tar and ammoniacal liquor per ton of coal; and by the imperfect method of condensation from open coke fires, as now described, even a larger quantity of liquid products is obtained. Every ton of coal coked in this manner yields from 30 to 40 gallons of ammoniacal liquor and gas tar; so that in works where 100 tons of coal per day are coked, at least 3000 to 4000 gallons are given off into the atmosphere daily in the shape of smoke and invisible vapour. How important must be the chemical changes which are constantly being produced in the atmosphere by the great manufacturing processes, but of the extent of which, in consequence of their being invisible, we are under ordinary circumstances utterly unaware. The results obtained and the chemical changes produced in a visible form by the new method of coking illustrate this remarkably: a continuous stream of liquid matter runs into the receiver, which but for this simple arrangement would have been all thrown away into the atmosphere. The excess of products condensed in this mode of coking, in comparison with those obtained by the condensation of gas made by distilling coal in closed retorts, is easily explained. In the open coking the coal is in wet weather saturated with moisture; the blacking used must of necessity be so; and in watering the fires, although the damper is closed at the bottom of the chimney, yet no doubt some aqueous vapour will pass by it into the main. But probably the greatest source of this excess is to be found in the water actually produced by the combustion of the hydrogen of the coal and the oxygen of the atmosphere.

In reference to the value of the products obtained, ammoniacal liquor and gas tar, the first is of course, from the excess of aqueous vapour just alluded to, weaker than the ammoniacal liquor of gas works: 750 gallons of the liquor saturate 72 lb. of sulphuric acid, and produce 112 lb. of sulphate of ammonia, a quantity which, though small in itself, is yet sufficient to be worth extracting commercially. The value of the second product, gas tar, has not as yet been fully ascertained: the analyses made of it however show that its constituents are very different from those of ordinary gas tar, and apparently more valuable. It does not contain so much naphtha, but a much larger quantity of the light photogenic oils now so extensively consumed in lamps, and a large quantity of paraffine.

The great variety of hydro-carbon products existing in gas tar, and their great and daily increasing value, owing to the numerous purposes to which they are now being applied, render any new means of obtaining them upon a large scale a subject of much interest. From them are now obtained naphtha, creosote, photogenic oils of light specific gravity admirably adapted for consumption in lamps, heavier oils for lubricating purposes, and paraffine, which is used as a substitute for wax in the manufacture of the best candles. Besides these, benzole and other compounds have recently been obtained, and are now employed largely in the production of the beautiful colours mauve and magenta, which have been so much used in dyeing during the last two or three years. So rapidly have the purposes to which these hydro-carbon products are applied been extended, that pitch, which was previously considered worthless for chemical purposes, and had accumulated at chemical works as refuse waste, has during the last two years become so much in demand, that it was its advancing price and the increasing difficulty of obtaining it that led to the experiments for collecting the products of combustion from open coke fires. The results show how boundless are nature's resources, when science discloses the means of utilising them. In the smoke which pollutes the atmosphere and destroys the beauty of the district, large stores of valuable matter are being wasted, which science shows may be employed not merely for the ordinary purposes of daily life, but also for those of decoration and ornament. Surely the time will come when science and manufactures will be brought into such close alliance with each other, that all that is now distasteful and unsightly in manufacturing processes, which is almost always connected with waste, shall disappear.

COMPETITIONS.

Designs are invited for a new building for the Ashton-under-Lyne and Dukinfield Mechanics' Institution, cost not to exceed £2500, exclusive of land. The building to comprise in two stories, a lecture-room to seat 500 persons, with ante-room contiguous, news room, conversation room, board room, secretary's room, library, four class rooms, rooms for keeper, and all necessary conveniences. Rooms to be heated with hot water, also flues provided for fireplaces in the various rooms, and a separate entrance to class rooms. Premium £26. 5s. Plans to a uniform scale of 8 feet to an inch, accompanied by a specification,—to be forwarded with letter containing motto and author's name, to G. Heginbottom, Esq. president, Ashton-under-Lyne, by the 25th inst.

The Committee of the Dalhousie Institute, Calcutta, invite architects to furnish designs and estimate for a building to be erected on the site on the Maidan. Copies of conditions of the competition furnished to applicants by R. C. Lepage and Co., No. 1, Whitefriars-street, London, E.C. First prize, 3000 rupees. Second prize, 1000 rupees. Designs will be received to March 31.

Plans are invited for laying out for building four acres of land in Plymouth. Premiums, £50, £25, and £10. Plans to be sent to Mr. William Derry, Houndiscombe House, Plymouth, by 1st March next.

THE STATICS OF BRIDGES.

Errata.

Page 1, col. 2, line 16 from top, for "remaining" read "reasoning."
,, 2, col. 2, line 15, for "present" read "presented."
Id., line 41, for "to" read "so to."

ARCHITECTS' CHARGES.

A law report has been forwarded to us, which contains matter of some importance, relative to a claim made by an architect at Liverpool for payment for plans and a specification of a building not erected. As condensed a statement of the case as can be made will no doubt suffice to point out its bearing upon future cases of the same nature, and upon architectural practice in general.

The plaintiff, Mr. Wylie, an architect of Liverpool, brought this action against the defendant, Mr. Willmer, under the following circumstances. The defendant had proposed to erect a large building, and it was admitted that a sum of £2000 was originally named, and subsequently a sum of £2500, as the cost of the intended structure. Numerous alterations were however introduced by the employer's wish; and ultimately tenders were obtained upon a bill of quantities prepared by another surveyor (who now by-the-by has the work in hand). The lowest tender was over £6000, upon which the client returned the plans, and told the architect he would have nothing more to do with him. The architect upon this sent in a bill for 2½ per cent. commission on the amount of this lowest tender. The employer declining to recognise any claim at all, the action was brought, and resulted in a verdict for the defendant; or in other words, in the jury deciding that the architect's claim for remuneration was unfounded.

The principal points of law and custom seem to have been these:—First, the *rate* of remuneration was not contested. Mr. Cunningham, an architect of good standing and practice, was called to prove that 2½ per cent. on the amount of the lowest tender (which was claimed) was the fair remuneration; but the counsel for the defendant observed, "We do not dispute the 2½ per cent," while the assessor before whom the case was tried —Mr. Edward James, Q.C.—narrowed the issue, by informing the jury, that in his opinion they had no right to award any *less* sum. The next point is the footing upon which the relation of architect and client was held to stand. The assessor, in his charge, observes of the architect, "That his right to recover depends upon the question of what the contract was between the plaintiff and the defendant."

> "If the architect is instructed to prepare plans and specifications for a building, the cost of which is not to exceed £2500 or thereabouts, a little more or a little less, he cannot expect to be paid if he prepares plans and specifications which are not applicable for such a building as that, but require the outlay of a sum considerably exceeding the limits of £2500, because his employment was to do a certain work. He has not done that work, but other work. He can therefore only recover in case he proximates to the contract which he has entered into with his employer —that is to do the work specified by the employer. Now the plaintiff's case is, that there were no such limits at all given to him—that he was employed to prepare plans and specifications."

In fact, the question at issue narrowed itself to this, whether the repeated modifications of plan had been constantly accompanied by a renewal of the instruction to abide by the original amount, or at least by an altered amount, of £2500, which was stated by the defendant to have been fixed by him at a later occasion as his limit; or whether they amounted to instructions to do a certain building regardless of cost. The architect's case is thus put on the summing up of evidence:—

> "'But,' says he, 'the defendant came from time to time, brought rough sketches of plans, and altered the building, which originally was to consist of two stories only and a cellar, to four stories and a cellar; and made a totally different description of building from what was originally contemplated; and he never specified to me anything about a limitation of money, but went on making these alterations, which would necessarily from time to time increase the expense. I obeyed him—what I did was by his direction—I did nothing without him; and therefore I am entitled to recover.' And he is quite correct in that; because if it were as he puts it—if, although originally the party contemplated a building to cost £1500 or £2000 only, and afterwards Mr. Willmer, without placing any limit on the amount to be spent, gave directions to the architect from time to time to alter his plans, to increase and expand them in such a way as that ultimately the plans and specifications required the outlay of £6350 at the very lowest, Mr. Willmer must pay for that, because it was his own fault in not limiting Mr. Wylie in the way in which he ought to have done. He cannot therefore turn round, and say, 'I won't pay for it, because it is not what I wish to have.' But on the other hand, if the case is as put by Mr. Willmer, and Mr. Fraser, who is with him—'that originally I contemplated £2000 to be spent, and distinctly told Mr. Wylie that that was my limit; and that afterwards, when I wanted alterations to be made, I invariably (and in that you have the evidence of Mr. Willmer and Mr. Fraser both to the same effect) told him that if the alteration would exceed, or render a greater expenditure of money necessary than my limit, I would not have it done"—then it is a very different matter. Upon one occasion Mr. Wylie said—'But it cannot be done for £2000.' Then said Mr. Willmer, 'Well, I will increase my limit to £2500, but within those limits you must keep.' And Mr. Fraser corroborates him; and they both say that, over and over again—Mr. Willmer says, twenty times at least—they told him he must not exceed £2500. Well, gentlemen, although it may be said, you cannot arrive accurately at what would be the cost of erecting buildings according to certain plans and specifications until the quantities are taken out, yet it is obvious that an architect of skill and experience would have some general knowledge which will keep him within certain limits, and certainly he ought to know the limits between £2500 and £6350. One of the witnesses called for the plaintiff, Mr. Culshaw, said it is obvious he must have done so. Mr. Cunningham said, of course they cannot know it accurately, but they must know to a certain extent. Well, if Mr. Willmer and Mr. Fraser are correct in what they say, undoubtedly there were limits beyond which Mr. Wylie was not to go: Mr. Wylie did go beyond them; he prepared plans and specifications which are not of any use at all to Mr. Willmer; and Mr. Willmer is not bound to pay for them."

The jury, as we have already stated, must have come to the conclusion that the instructions to adhere to the sum of £2500 had been repeated whenever alterations had been commissioned (and this seems to have occurred daily); for they, after inquiring if they could award a smaller amount, and being told they could not, returned a verdict against the claim.

It is difficult to see how they could have done otherwise, considering the charge they received, though the result cannot be considered as altogether satisfactory. There is no question that the professional man did work and spent time at the commission of his client, and that he is not to be paid for it. There is no question also that he, in every point save the question of amount, carried out the instructions of his employer, who daily superintended the progress of the drawings; and it is self-evident that if he received instructions to adhere to one amount, and at the same time instructions to go to an extent which reached more than double that amount, his instructions were contradictory. He probably followed the most peremptory, and in his evidence states that he disclaimed any responsibility as to cost.

> "Mr. Willmer once asked him if he thought the building could be erected for £3500. That would be, he thought, about the latter end of September. He replied, 'Mr. Willmer, you are continually making alterations, and until those alterations are completed it is impossible to know what the building will cost.'"

It seems to us far from clear that the architect ought to have gone entirely without remuneration, notwithstanding that the discrepancy was so great between the proposed estimate and the actual lowest builder's tender; but it is very clear that, to carry out the principle to cases where such a discrepancy is small, would introduce great injustice.

It is again to be regretted that in the architect's case the different series of instructions given him, and their effect in adding to cost, were not traced from first to last, one by one. Had materials for this existed, and had this course been followed, the plaintiff could have probably shown that alterations were proposed to him which manifest on the face of them that they *must* have been accompanied by an addition of cost. Any jury can understand that, if a building covering a certain space costs a thousand pounds when forty feet high, it must cost something more to make it fifty feet high. We presume this was not possible, for had it been it would have probably established the plaintiff's case. An architect who anticipates many alterations on any work, had better keep a little journal of the orders received and modifications made,—to be preserved along with the papers relating to that work, and to contain memoranda of all orders involving alterations as they are given, whether to him by his client, or by himself to the builder.

These instructions are in truth the feature in the case that causes us to hesitate as to the propriety of the settlement; under other circumstances there could be no doubt. Where an architect has works left to a great extent in his hands, it is his duty, if he receives instructions as to expense at all, to abide by them. It is not always the duty of an architect to know the cost of proposed works—it is not always in his power; but it is always both his duty and in his power to be straightforward. Unfortunately, instances frequently occur even in plain and ordinary works (where there is no difficulty about forming an approximate estimate, and where the cost is a matter of importance to the employer), that a certain class of architects will send in with their plans estimates which they either know or *ought to know* are fallacious in the extreme; and as the actual cost is not discovered either till the work is done, or at any rate until all preliminaries are completed, it sometimes happens that the proprietor is obliged to go on at a rate of expenditure that he did not contemplate, and leaves off with no very kindly feelings towards architects. It is to be hoped that the present decision will check this sort of thing, and that the architects who, either from carelessness or wilful neglect, have failed to give to their estimates the attention they require, will, now that their own remuneration is shown to be endangered, pay a litttle more regard to this very essential part of their professional duties.

So much for law. As for desirableness or expediency, no one can question that the occurrence of such *contretemps* is most undesirable. Architects should early come to an understanding with their employers as to the question of cost; they should acquaint themselves with all the usual methods of approximate estimating, and should employ them: but where working for private clients it is especially desirable to have the approximate estimates prepared by a third person. It is also well to have estimates made of every important modification; and it is especially to be recommended as prudent, if the architect and client have an important conversation in which the basis of future operations is settled, that the architect should sit down, while the recollection of all that has passed is fresh on his mind, and write his impressions of the arrangement come to—send a copy of them to his employer, ask if they are correct, get an answer, and *keep it.* Above all, it is due to himself for the architect to stand out for a liberal estimate in the first instance: it will save him a world of trouble, and the client a world of disappointment.

Little of this however can take place when the work is gained by public competition. In nineteen cases out of twenty, the selected plan, if not chosen because it is the work of a friend, is selected because its author, notwithstanding that it is among the most ornamental submitted, declares that it can be carried out for a sum which any man of judgment would know to be absurdly below even a probable amount. From so auspicious a commencement flow results which there is no reason to question have damaged the standing of the profession, and have deteriorated the moral character of many of its members. It is therefore to be earnestly desired, that in all cases where clients treat their architect with that confidence without which no professional man can act comfortably, he should do them justice. No client can expect to be well served, either by his lawyer, his doctor, or his architect, unless he makes the professional adviser understand that he is at perfect liberty safely to tell him an unpleasant truth if it be necessary. If the architect is not made to feel that this confidence is reposed in him, the client must expect to suffer. If however such confidence is bestowed, the architect ought to be both skilful enough and honest enough to repay it, by knowing within a moderate limit what can and what cannot be done for a given sum of money; and by unreservedly and frankly laying the state of the case before his client.

◆

THE STATICS OF BRIDGES.

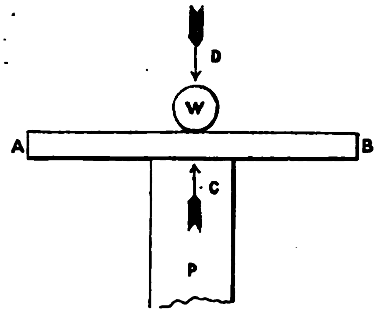
(Continued from page 2.)

II.—*The Duty of a Bridge, and the Theory of Moments.*

In the inquiry which we have proposed to lay before our readers we may at once disclaim all pretension to having any new truths to impart on a subject which has been so long, so profoundly and variously studied by many able men. It will be our sole endeavour to exhibit known, and generally speaking very old truths; putting them in their simplest form, and arranging them in such order as may best guide us in the investigation upon which we are about to enter. But familiar and even trite as the subject of our study may be, no prescription is imposed upon us as to the method of examining it: in this respect, while novelty is not to be sought for its own sake, we are not to be deterred from striking out a new path, so it enable us to follow more closely the simplicity of truth. It will be an ample recompense to our labours if, without discovering a single novel fact, we are enabled to reflect any light on those which are generally admitted;—so far to map out what is self-evident or well known as to define the limits of what is obscure;—or to discern a unity of principle under every diversity of form and action. But this issue is only to be sought with the patience and humility proper to learners. We must endure to begin with very obvious truths; to proceed slowly and circumspectly at the outset; and scrupulously to examine those cases especially in which it has most been our habit to take things for granted.

To look at a bridge in the most general way, we have rather to consider the task which is imposed upon it than the peculiarities of its construction. The duty of a bridge is to sustain a load between points of support which are separated by a considerable horizontal interval. The downward pressure of the load has thus to be transmitted along the structure of the bridge towards these points, where it meets with the upward reactions that furnish its ultimate, as the bridge has furnished its immediate, support. In discharging this duty the bridge is exposed to forces that tend to make its parts rotate in opposite directions. Thus, if a bridge of one span were divided at any point, the direct pressure of the load would operate to make either part turn downwards on its point of support as on a fulcrum, the directions of rotation of the two parts being contrary. A bridge is so contrived, that these tendencies of its parts to rotate in opposite directions under the action of the load give rise to reactions which insure the equilibrium of the whole. A little further consideration will render this sufficiently obvious.

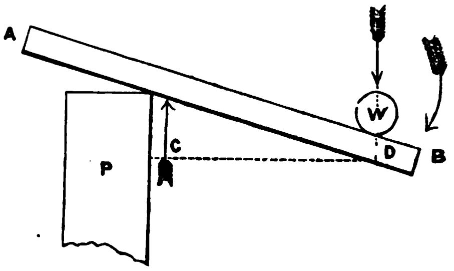
Fig. 1.



If a load W rests on a beam AB, which again rests on a pier P vertically under the load, as in Fig. 1, the whole arrangement will of course be stable. But if, as in Fig. 2, the pier P is not vertically under the load W, the beam will turn over. The downward pressure of W where it rests on the beam may be represented in magnitude and direction by the arrow D. An equal downward pressure is transmitted by the beam to the pier, where it is met by a vertical reaction, which may be represented by the arrow C, of the same length as D, and in the opposite direction.

In Fig. 1, the arrow C being immediately under the arrow D, the reaction neutralises the action, and no motion takes place. But in Fig. 2 the vertical directions of these arrows are separated by the horizontal distance CD. In this case the action of the weight and the reaction of the pier cause the beam AB to turn round, in the same way that the power applied to a lever and the reaction of the fulcrum turn a lever. The leverage in the present case is the horizontal distance CD; and the number of cwts. or tons in the weight W, multiplied by the number of feet in CD, is the *moment*, or in other words the rotatory force tending to turn the beam AB in the direction of the curved arrow.

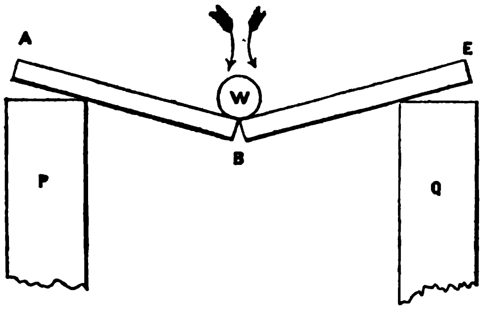
Fig. 2.



Now suppose W, instead of resting on one beam, to be placed on two beams, AB and BE, at the point B where their ends meet; their other ends resting on the piers P, Q (Fig. 3): W will turn both these beams down, and it is evident that the rotations of AB and BE will be in opposite directions, as shown by the curved arrows.

Let us now suppose the beams AB, BE to be put slanting up against each other at B, as in Fig. 4, and recesses or skewbacks to be cut in the piers for the lower ends A, E, of the beams to abut against. The load W being placed at B, AB and BE have a tendency to turn downwards, towards the position, say, shown by the dotted beams AF and FE. But AF and FE are shorter than AB and BE, so that the beams could not reach this position without being compressed or crushed so as to shorten their original lengths; unless the piers P, Q, were thrust apart, so as to lengthen the distances from A to F and from E to F. If then the piers are sufficiently firm to maintain their position, and the beams strong enough to resist compression, the structure ABE will preserve its form and carry the load W. Thus the opposite moments of AB and BE are brought to counteract each other by means of compression or thrust, so as to secure the equilibrium of the whole. This exhibits the principle of the arch in its simplest form.

Fig. 3.



Again, suppose some such arrangement as in Fig. 5, AB and BE being links, connected by a hook and eye at B, where the weight W is hung, and the ends A and E being supported by hooks fastened to the piers P, Q. In this case the pressure of the load gives rise to moments in the two links tending to depress them into the position AF, FE. But AF and FE are longer than AB and BE; so that if the piers are firm enough to resist being drawn inwards, and the links AB and BE strong enough to resist stretching or rending, no change of form will take place, and equilibrium will ensue. Here we may recognise the suspension chain reduced to its simplest form.

Fig. 4.

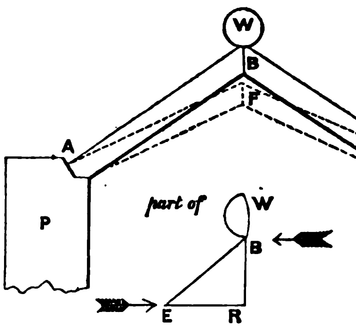


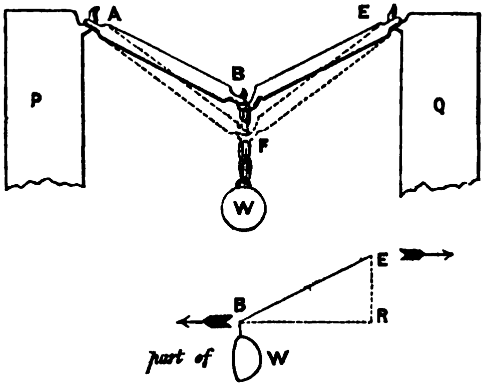
Fig. 6 shows a third, and that the most obvious, arrangement for securing stability. This is simply to unite the beams AB and BE into one continuous beam. The weight W tends to turn AB and BE different ways as before, but this tendency will now be effectually checked unless its operation is powerful enough to *break* the beam at B: and depression will take place so far only as the opposing moments are sufficient to cause the beam to *bend* at B (and elsewhere). Equilibrium here results from the transverse strength of the beam and its inflexibility; or, more strictly speaking, from the elastic forces brought into play by flexure. In this consists the stability of the girder.

While then the girder sustains a transverse strain, and conveys merely a vertical pressure to the piers, the simple forms of arch and chain shown in Figs. 4 and 5 are exempt from transverse strain, and derive their stability from a horizontal reaction at the piers: the arch being altogether in compression, and exerting an outward thrust against the piers; while the chain is entirely in tension, and exerts a force tending to draw the piers inwards.

Since no material is absolutely incompressible, it follows (to revert to Fig. 4) that the lengths of AB and BE will in some small degree become reduced through the thrust they undergo in supporting the load W; and the apex B must therefore sink to such an extent as to keep their ends in contact when thus shortened. This small depression or deflection is commonly known in an arch as "settlement." In order to the stability of ABE under the load W, a certain amount of thrust must be exerted against the piers. This can only take place through certain compressive forces being brought into play; in order to which result, AB and BE must be actually compressed or shortened to some definite extent by the settlement of the apex B. This settlement will therefore begin as soon as the load is placed on the arch, and increase until AB and BE are sufficiently compressed to produce the requisite thrust: as soon as this takes place the loaded arch will be in a state of equilibrium, and any further deflection will be arrested.

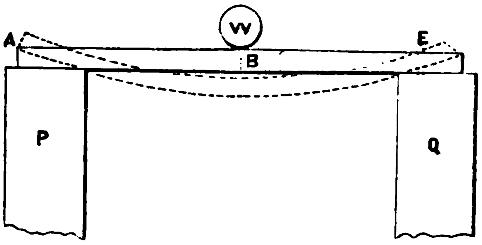
In the same way, in Fig. 5, the amount of tension caused by the load W will stretch the links to a certain degree, so as to cause deflection. As soon as the necessary amount of deflection is produced, the loaded chain will have attained a condition of equilibrium. And in the girder, Fig. 6, a certain amount of bending, and consequent deflection, must take place before the beam can put forth the requisite transverse strength. On this deflection being reached, a stop is put to the further change of form which the opposite ponderating moments of the parts AB and BE have a tendency to produce.

Fig. 5.



In any bridge, therefore, no matter of what form, the load must cause a certain degree of deflection, in order to bring those forces of reaction into play on which equilibrium depends. With these forces of reaction and their different modes of operation we do not propose, however, at present to concern ourselves. The matter to be first considered is the nature and the amount of those ponderating moments of rotation with which, as we have already seen, the load affects the various parts of the bridge. As this question is dependent on the theory of couples, it becomes necessary to ascertain the principles by which in accordance with that theory our calculations should be governed. This we will endeavour to do in three propositions.

Fig. 6.



Proposition 1.—Any two systems of parallel pressures, equal in amount and diametrically opposite in direction, will either hold each other in equilibrium, or have a definite moment of rotation, the amount of which is *independent of the position assigned to the centre of rotation*.*

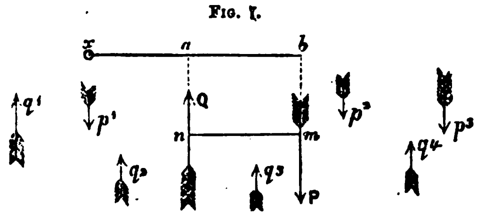
If the resultants of the two systems are in the same straight line, the result will be equilibrium; if not in the same straight line, rotation. Take the latter case (see Fig. 7).

Let p_1, p_2, p_3, and q_1, q_2, q_3, q_4, be two sets of parallel but opposite pressures in one plane, having equal resultants represented in position and amount by the arrows P and Q. The product of one of these resultants and the perpendicular distance *mn* between them represents the moment of rotation of the combined system of pressures about any centre in the common plane. Suppose *x* is the centre of rotation, and draw the line *xab* parallel to *mn* and meeting the directions of the resultants in *a* and *b*.

---

* Algebraically speaking, if the sum of a system of parallel pressures is nothing, the moment of the system is a constant independent of the position of the centre of rotation.

Fig. 7.

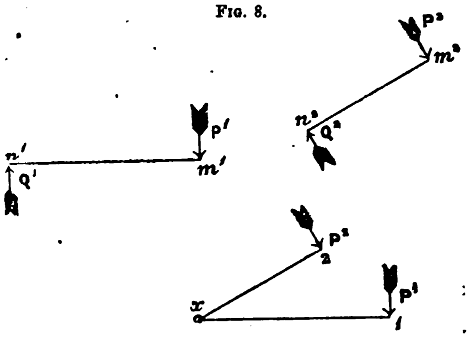


The pressures *p* will have a resultant downward moment about *x* equal to $P\times bx$; and the pressures *q* will have a resultant upward moment equal to $Q\times ax$, or $=P\times ax$, since $Q=P$. The common moment of all the pressures about *x* will therefore be equal to $P\times bx-P\times ax=P\times ab$, $=P\times mn$, because $ab=mn$.

Proposition 2.—If there be two pairs of sets of equal and opposite parallel pressures, the common moment of the whole system will be equal to the sum of the moments of the two sets if both are in the same direction of rotation, or to their difference if they are in opposite directions.*

In Fig. 8, let P_1 and Q_1 be the resultants of the first pair of sets of parallel pressures, at a common distance m_1n_1; and let P_2 and Q_2 at a distance m_2n_2 be the resultants of the second pair. The moment of the first pair being $P_1\times m_1\,n_1$, and the moment of the second being $P_2\times m_2n_2$, the sum of these moments is the common moment of the whole system.

Fig. 8.



This becomes evident on assuming a common centre of rotation *x*, and drawing *x*1 equal and parallel to n_1m_1, and *x*2 equal and parallel to n_2m_2. For the first pair cause the same moment of rotation about *x* as if P_1 were applied at 1, and Q_1 supplied the reaction of the centre at *x*. And in the same way, the second pair cause the same moment about *x* as if P_2 were applied at 2, and Q_2 at *x*. It is therefore plain that the common moment about *x* is the sum of these moments, their directions of rotation being the same; and would have been their difference, had they been in opposite directions.

Proposition 3.—If any set of pressures in one plane are in a state of equilibrium, the sum of moments tending to cause rotation in one direction must be equal to the sum of moments in the opposite direction.†

If the pressures are not all parallel, they can by the parallelogram of pressures be resolved into pressures parallel to two straight lines; and these pressures can again be reduced to pairs of opposite resultants: this proposition will then evidently follow from Prop. 2.

Let us now consider the moments of the load carried between the points *a* and *b* (Fig. 9).‡

The distance *ab* is divided at the points 1, 2, 3, &c. into equal intervals, each $=d$; the load being divided into corresponding portions, represented by the rectangles l_1, l_2, l_3, &c., the sum of which is equal to L, the entire load. A is the vertical reaction at the point of support *a*, and B is the reaction of the support at *b*. As the whole load is supported by the reactions at these two points, it is plain that $A+B=L$. If therefore A equal the portion of the load from *a* to 8, B must equal the remainder from 8 to *b*. It will be sufficient to consider the moments from *a* to 8, as the same method will be applicable to those from 8 to *b*.

The upward pressure arising from the reaction at A is transmitted, through the structure that carries the load, from *a* to 8, but at the same time successively reduced by the action of the portions l_1, l_2, &c. of the load. Thus,

At *a* the reaction $=A\ =l_1+l_2+l_3+\dots\dots\dots l_8$
At 1 „ $=A-l_1\ =l_2+l_3+\dots\dots\dots l_8$
At 2 „ $=A-l_1-l_2\ =l_3+\dots\dots\dots l_8$

and so on. At 8, reaction $=0$.

The portion l_8 of the load is subject to the action of its own weight acting at its centre of gravity g_8,* and the vertical reaction $=l_8$ at 7. These opposing pressures create in l_8 a moment equal to $\frac{1}{2}d\times l_8$. The pressures acting on l_7 are—

A downward pressure $=l_8$ at the point 7;
Its own weight $=l_7$, acting at its centre of gravity g_7; and,
The upward reaction $=l_7+l_8$, at the point 6.

These pressures are resolvable into two pairs,—viz.

l_8 downwards and l_8 upwards, at a distance *d*; and

l_7 downwards and l_7 upwards, at a distance $\dfrac{d}{2}$.

The sum of these moments is the moment of l_7; or, moment of l_7 is equal to $\frac{1}{2}d\times(l_7+2l_8)$.

In the same way, l_6 is subjected to the following forces:—

Action $=l_7+l_8$, at the point 6;
Action $=l_6$, at the centre of gravity g_6; and
Reaction $=l_6+l_7+l_8$, at the point 5;

and the moment of l_6 is equal to $\frac{1}{2}d\times(l_6+2l_7+2l_8)$.

By similar reasoning, the other moments are obtained, as follow:—

Moment of $l_5=\frac{1}{2}d\times(l_5+2l_6+2l_7+2l_8)$.
„ $l_4=\frac{1}{2}d\times(l_4+2l_5+2l_6+2l_7+2l_8)$.
„ $l_3=\frac{1}{2}d\times(l_3+2l_4+2l_5+2l_6+2l_7+2l_8)$.
„ $l_2=\frac{1}{2}d\times(l_2+2l_3+2l_4+2l_5+2l_6+2l_7+2l_8)$.
„ $l_1=\frac{1}{2}d\times(l_1+2l_2+2l_3+2l_4+2l_5+2l_6+2l_7+2l_8)$.

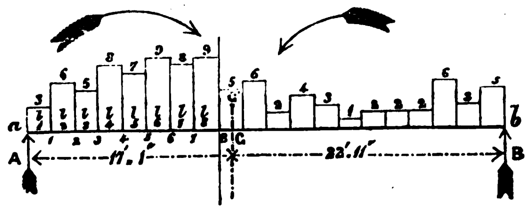
Thus, the moment of any section l_n is of the form $\frac{1}{2}d\times m_n$, of which the first factor is constant and equal to half the common interval *d* between the points of section, and the second factor follows the simple law that $m_n=m_{n+1}+l_{n+1}+l_n$.

Thus, m_8 (with which we start) being $=$ l_8
To find m_7, add to m_8, l_8 and l_7 … … l_7+l_8
Which gives m_7 $=$ l_7+2l_8
To find m_6, add l_7 and l_6 … … l_6+l_7
Which gives m_6 $=$ $l_6+2l_7+2l_8$

and so on.

We have thus divided the portion *a*8 of the load, equal to the pressure of reaction A, at equal intervals into the sections l_1, $l_2\dots\dots l_8$; and seen how by simple additions to determine the factors m_1, $m_2\dots\dots m_8$, which, when multiplied by half the common interval, will give the respective moments of these sections.

Fig. 9.



Since all these moments tend to rotation in the same direction, it follows from Prop. 2, that if we take two or more adjacent sections together, the common moment of the portion of the load which they compose will be equal to the sum of their several moments.

Thus, the moment of the portion of load from *a* to 2 (or l_1 and l_2) will be equal to $\frac{1}{2}d\times m_1+\frac{1}{2}d\times m_2=\frac{1}{2}d\times(m_1+m_2)$. The moment of the portion of load from *a* to $3=\frac{1}{2}d\times(m_1+m_2+m_3)$; and the entire moment of *a*8 is equal to the sum of all the moments, or $=\frac{1}{2}d\times(m_1+m_2+\dots\dots m_8)$. The same process is equally applicable to the other portion of the load (from 8 to *b*), the moment of which will be in the opposite direction.

---

* Algebraically speaking, the moment of the whole system is equal to the sum of moments of the parts, with their proper signs.

† Algebraically expressed by saying, that if a system of pressures is in a state of equilibrium, the sum of their moments is equal to nothing.

‡ The span between the points of support in Fig. 9 is supposed to be 40 feet, the equal intervals, 2 feet each. The weight in cwts. of each portion of the load is given, and the position of the centre of gravity figured, to enable the reader, if so disposed, to go into the question arithmetically.

* The centres of gravity g_8, g_7, &c., are supposed to be midway between the points 8, 7, 6, &c., but are not marked in the diagram, to avoid confusion.

By the method just explained, a process of continued addition twice gone through;—the first time from 8 to *a*, the second time from *a* to 8;—yields a series of factors, which when multiplied by $\frac{1}{2}d$ give the moments of the section *a*8 and of all lesser sections; the section *a*8 being supposed to comprise such a portion of the load as will be just equal to the reaction A. To apply this method, it is necessary to know the reaction A, in order to find the point 8, where the vertical reaction vanishes and the load naturally divides into two portions having opposite moments.

When the pressure of the entire load L, acting at its centre of gravity G, is in equilibrium with the vertical reactions at *a* and *b*, (which will be the case when the load is carried by a girder having its ends at *a* and *b* perfectly free; or by a chain having its ends fixed at the same level; or when the load is symmetrically disposed over a symmetrical arch); it is easy to determine A and B after fixing the position of G.

To fix G, take once l_1, twice l_2, thrice l_3, and so on from *a* up to *b*; divide the sum by L; multiply the quotient by the common interval *d*; the result, less $\frac{1}{2}d$, will be the distance of G from *a*. Or,

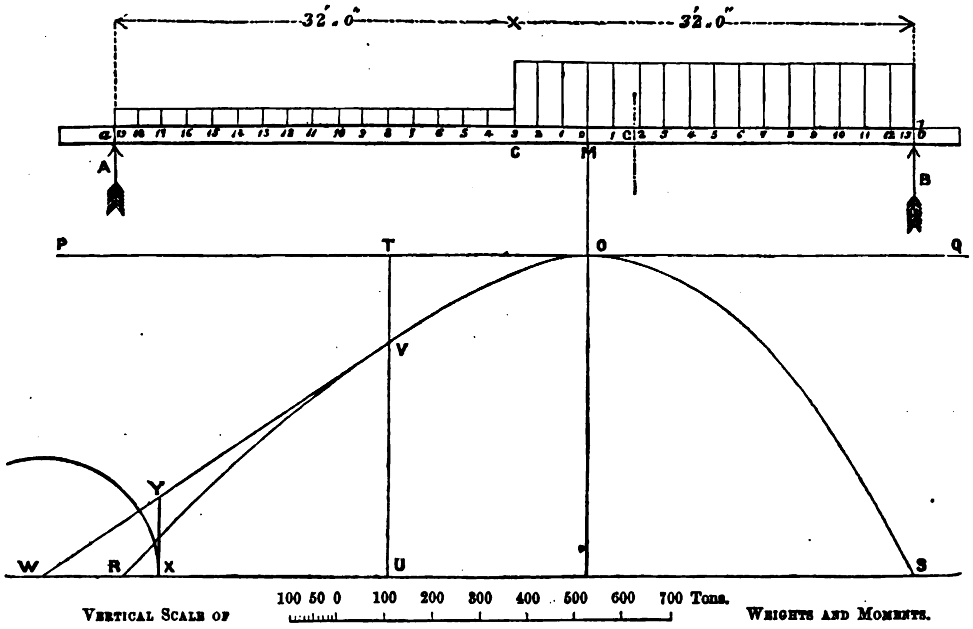
$$\frac{l_1+2l_2+3l_3+4l_4+\ldots\ldots(\text{up to } b)}{\mathrm{L}}\times d-\tfrac{1}{2}d=\text{the distance } a\mathrm{G}.$$

Since the pressure L, (=A+B), of the load, acting at G, is in equilibrium with the reactions A and B at *a* and *b*; and since these pressures can be resolved into the couple A and A, at the distance *a*G, tending to rotation one way, and the couple B and B, at the distance G*b*, tending to rotation the opposite way; these opposing moments must (Prop. 3) be equal; or, A×*a*G=B×*b*G; from which it follows that

$$\mathrm{A}=\mathrm{L}\times\frac{b\mathrm{G}}{ab},\ \text{and}\ \mathrm{B}=\mathrm{L}\times\frac{a\mathrm{G}}{ab}$$

In this case, the moment of the section of the load (*a*8) is equal to the opposite moment of the remaining section (*b*8). In any case, the point where the load naturally divides, as at 8, is that of Greatest Moments, the opposing moments each reaching a maximum at that point.

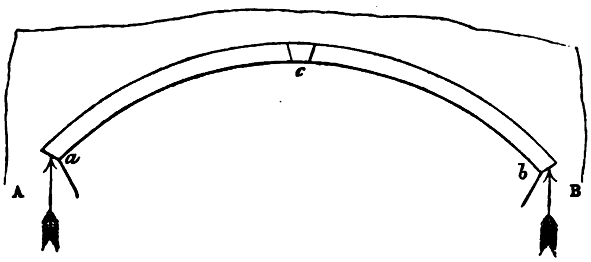
Fig. 11.


32' 0"
32' 0"
a
b
A
B
C
M
C
P
T
O
Q
V
Y
W
R
X
U
S
100 50 0 100 200 300 400 500 600 700 Tons.
Vertical Scale of Weights and Moments.

The point of Greatest Moments is also (as we have seen) that at which the vertical reaction transmitted from either point of support vanishes. If the structure which carries the load is incapable of transmitting vertical reaction from either support beyond a certain point, that point will consequently be the point of Greatest Moments.

Take for instance a masonry arch (Fig. 10). No part of the vertical reaction from *a* can be transmitted beyond the crown at *c*; for this could not be conceived without supposing some of the voussoirs beyond *c* to *hang* from the keystone, which is not consistent with the nature of masonry. Therefore *c* must be the point of Greatest Moments, the load dividing there, so that the vertical reaction A is equal to the load (including masonry) from *a* to *c*, and B is equal to the load from *c* to *b*: and this even if the two sides of the arch are very unequally loaded; in which case the weight of the load, acting at its centre of gravity, will no longer be in equilibrium with the vertical reactions at the points of support. How this is met will be seen when discussing the theory of the arch.

Fig. 10.



The method of computing the moments by addition will be made plainer by taking an example. Fig. 11 represents a load carried by a girder between abutments at *a* and *b*, the ends of the girder being free. The span of the girder is 64 feet: of this length one half, or 32 feet (from *a* to *c*), is loaded uniformly at the rate of half a ton per foot forward; the other half is uniformly loaded at the rate of 2 tons per foot forward. The load is subdivided into 32 sections at equal intervals of 2 feet. Thus the 16 sections from *a* to *c* will each weigh 1 ton, and the 16 sections from *c* to *b* will weigh 4 tons each; and the total load will be 80 tons.

The first step is to determine the position of the centre of gravity G. This is found by the formula,

$$\frac{1+2+3+4+\ldots\ldots16+17\times4+18\times4+\ldots\ldots32\times4}{80}\times2-1=a\mathrm{G};$$

or,

$$\frac{\frac{16}{2}\times17+\left(\frac{32}{2}\times33-\frac{16}{2}\times17\right)\times4}{80}\times2-1=a\mathrm{G}.$$

Therefore *a*G=41′·6, and G*b*=22′·4.

Having the position of G, we can now find the values of A and B, the reactions at *a* and *b*.

$$\mathrm{A}=\mathrm{L}\times\frac{b\mathrm{G}}{ab}=80\times\frac{22\cdot4}{64}=28\ \text{tons; which leaves B}=52\ \text{tons.}$$

A being 28 tons, to find the point of greatest moment we must take such a portion of the load, reckoning from *a*, as will amount to 28 tons. This fixes the point of greatest moment at M, 6 feet from *c*, and 38 feet from the abutment *a*. It will prove convenient to call this point zero, and to number the points of subdivision from it towards the abutments on either side. This will give Nos. 0 to 19 from M to *a*, and 0 to 13 from M to *b*.

Table I. shows the mode of computing the moments of the load from *a* to M by simple addition. The first line, marked "No." gives the numbers of the respective lines of subdivision. The second line, marked "W," gives the weight in tons of each section. The fifth line, marked "M," gives the respective values of the factor *m* for each section.

TABLE I.

To check the work in the line M, observe that the *last number* (55), added to the *last weight* (1) gives *twice* the total load from 0 to the abutment, (56 = 2 × 28). To check the work in the line S, observe the last total (676) is the sum of the numbers in the line M.

19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	No.
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	W
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	...	*w*
	53	51	49	47	45	43	41	39	37	35	33	31	29	27	25	20	12	4	...	*m*
	55	53	51	49	47	45	43	41	39	37	35	33	31	29	27	25	20	12	4	M
	...	55	108	159	208	255	300	343	384	423	460	495	528	559	588	615	640	660	672	*s*
	55	108	159	208	255	300	343	384	423	460	495	528	559	588	615	640	660	672	676	S

The weight of (0, 1) is 4: and the value of *m* for this section is 4; its moment being half the common interval multiplied by 4. The weight of (1, 2) is 4: to this weight we add, on line *w*, the *weight* of preceding section (=4), and, on line *m*, the *moment* of preceding section (=4); the sum (=12) is the value of *m* for (1, 2). The same process is continued, as shown by the diagonal lines, to find the successive values of *m* up to 55 for the section (18, 19). Then, by continual addition backwards,—the last sum being brought forward on the line *s*, as indicated by the diagonal lines,—the numbers on the line S are obtained. Thus, for the portion of load from 19 to 13, S=300; and 300 multiplied by 1 (the half of 2, the common interval) is the moment of (19, 13), and the transverse strain in tons on the girder at 13. So again, the moment of (19, 12) is 343×1; the moment of (19, 11) is 384×1; and the greatest moment, or that of the load from 19 to 0, is 676×1.

TABLE II.

No.	0	1	2	3	4	5	6	7	8	9	10	11	12	13
W		4	4	4	4	4	4	4	4	4	4	4	4	4
M		4	12	20	28	36	44	52	60	68	76	84	92	100
S		676	672	660	640	612	576	532	480	420	352	276	192	100

Table II. shows the steps of the process for finding the moments from M to *b*; the lines *w*, *m*, and *s* being omitted, as no longer necessary for explanation. The first process of addition, for finding the figures in the line M, is in this table from left to right, 0 being at the left hand: the second addition, for finding S, is from right to left. Each step may be easily performed in the head. Thus, in the line M: for section (1, 2)—"4 and 4 are 8, and 4 are 12;" for section (2, 3)—"12 and 4 are 16, and 4, 20;" and so on. The simplicity of this process is extreme as compared with the usual method of finding the units of strain on a beam, on the assumption that every part of the load derives support from both abutments. The results are identical, the essential principle involved, that of the lever, being the same in both cases.

Suppose, for example, it is required to find the units of strain at *c* (or the moment of the load *ac*) on the hypothesis usually adopted in the case of girders. The section (18, 19) weighs 1 ton: its centre of gravity is distant 1 foot from *a* and 63 feet from *b*. The portions of its weight transmitted to the abutments *a* and *b* must be inversely as these distances: so that $\frac{1\times 63}{64}$ tons will be transmitted to *a*, and $\frac{1\times 1}{64}$ tons transmitted to *b*.

Thus, (18, 19) causes two opposite moments in *ac*. The first, due to the portion $\frac{1\times 63}{64}$ tons and an equal reaction at *a*, at the distance of 1 foot, will be equal to $\frac{1\times 1\times 63}{64}$. The second, due to the remainder of $\frac{1\times 1}{64}$ tons and an equal reaction at *c*, at the distance of 31 feet, will be equal to $\frac{1\times 1\times 31}{64}$. The difference of these moments, $=\frac{1\times 1\times 63}{64}-\frac{1\times 1\times 31}{64}=\frac{1\times 1\times 32}{64}$, is the moment which, on the whole, (18, 19) causes in *ac*; and this gives the amount of strain produced at *c*, since an equal and opposite moment $\frac{1\times 1\times 32}{64}$ which is created in *bc*.

By similar reasoning, (17, 18), also weighing 1 ton, having its centre of gravity distant 3 feet from *a*, creates at *c* a strain equal to $\frac{1\times 3\times 32}{64}$; (16, 17) will cause a strain $=\frac{1\times 5\times 32}{64}$; and so on.

The strain at *c*, arising from that part of the load which lies between *a* and *c* will thus be=

$$\frac{1\times 1\times 32}{64}+\frac{1\times 3\times 32}{64}+\frac{1\times 5\times 32}{64}+\frac{1\times 7\times 32}{64}+\frac{1\times 9\times 32}{64}+$$
$$\frac{1\times 11\times 32}{64}+\frac{1\times 13\times 32}{64}+\frac{1\times 15\times 32}{64}+\frac{1\times 17\times 32}{64}+\frac{1\times 19\times 32}{64}$$
$$+\frac{1\times 21\times 32}{64}+\frac{1\times 23\times 32}{64}+\frac{1\times 25\times 32}{64}+\frac{1\times 27\times 32}{64}+$$
$$\frac{1\times 29\times 32}{64}+\frac{1\times 31\times 32}{64}=\frac{256\times 32}{64}=128 \text{ tons.}$$

To this has to be added the strain due to the further moment created in *ac* by the rest of the load, which extends from *c* to *b*. (2, 3) weighs 4 tons, and has its centre of gravity 33 feet distant from *a*, and 31 feet from *b*. The portion $\frac{4\times 31}{64}$ of its weight will be transmitted to *a*. This will cause an action at *c* and a reaction at *a*, each equal to $\frac{4\times 31}{64}$; and the distance *ac* being 32 feet, the moment created will be $=\frac{4\times 31\times 32}{64}$. In the same way, (1, 2) creates a strain at $c=\frac{4\times 29\times 32}{64}$; and so on, down to (12, 13), which causes a strain $=\frac{4\times 1\times 32}{64}$.

The sum of all these strains $=\frac{4\times 31\times 32}{64}+\frac{4\times 29\times 32}{64}+$

$$\frac{4\times 27\times 32}{64}+\frac{4\times 25\times 32}{64}+\frac{4\times 23\times 32}{64}+\frac{4\times 21\times 32}{64}+\frac{4\times 19\times 32}{64}$$
$$+\frac{4\times 17\times 32}{64}+\frac{4\times 15\times 32}{64}+\frac{4\times 13\times 32}{64}+\frac{4\times 11\times 32}{64}+\frac{4\times 9\times 32}{64}$$
$$+\frac{4\times 7\times 32}{64}+\frac{4\times 5\times 32}{64}+\frac{4\times 3\times 32}{64}+\frac{4\times 1\times 32}{64}=\frac{4\times 256\times 32}{64}$$

=512 tons, and this is the strain at *c* due to the load from *c* to *b*.

The total strain at c is therefore $=128+512=640$ tons, which is the same result as was arrived at by the method of continued additions at the point 3, which is the same as c. To find the strain at any other point by the ordinary method, a similar process would have to be gone through again, as the work done in finding the strain at 3, for instance, is of no assistance towards finding the strain at 2. And three or four such trials would be necessary to find the point of greatest strain.

By the method of continued additions, on the contrary, one process determines both the greatest strain and the strains at all other points. In effect, when we know the point (M) of Greatest Moments, we may consider the load as dividing itself at that point into two parts; of which one (aM) derives its support entirely from the abutment a, and the other (Mb) entirely from the abutment b. The conclusions to which this assumption leads us are equally true whether the structure carrying the load is an arch, a chain, a girder, or a combination of these forms. The moments of the load, which are the same as the units of strain on a girder, are capable of being determined by two simple processes of continued addition, easily checked, which give at once the greatest moment and all lesser moments; without having recourse either to multiplication by fractions or to the successive finding of centres of gravity for the different parts of the load. This method may be generalised by the use of algebra, so as to lead to some useful deductions.

Reverting to page 62 and Fig. 9, let l be taken to denote the variable load, measured from the point of Greatest Moments (8) to any assigned point between 8 and a; and let x stand for the corresponding horizontal distance measured from 8, as an origin, towards a. Then Δx will denote d, and l_8, l_7, &c. will be the various values of Δl.

The moment of $l_5=\frac{1}{2}d\times(l_5+2l_6+2l_7+2l_8)=d\times(\frac{1}{2}l_5+l_6+l_7+l_8)$. Of this expression the first factor is $=\Delta x$, and the second factor equals the amount of load from the origin to a point half-way between 4 and 5 (or to the centre of gravity of l_5). The equation may therefore be thus expressed:—moment of $\Delta l=l\times\Delta x$, an equation which applies equally to all the other moments, as will be evident on looking at the expressions previously given for them.

Now the collective moment of any number of consecutive sections, as l_8, l_7, l_6, is the sum of their respective moments. Therefore, if m denote the moment of the variable load l, m will be the sum of the moments of l_8, l_7, &c. up to x: so that $\Delta m=$ moment of Δl. Consequently, $\Delta m=l\times\Delta x$. If the number of points of subdivision be increased without limit, so that d (that is Δx) is diminished without limit, this equation will assume the following form: $dm=l\,.\,dx$; whence it results that $m=\int l dx$. This is the algebraic expression for the moment of a given load at any assigned point. It also follows that $\frac{dm}{dx}=l$, that is to say, that the differential coefficient of the moment with respect to x is equal at any point to the load from the origin (or point of greatest moments) to that point. Differentiating again, we find that $\frac{d^2m}{dx^2}=\frac{dl}{dx}$; or, the second differential coefficient of the moment at any point is equal to the *rate of loading*.

ROS in Fig. 11 is a curve of which the vertical ordinates represent the moments of the load carried by the beam acb, plotted to an arbitrary vertical scale of weights and moments. Thus, the moment of (0, 8) is proportional to the corresponding ordinate TV, measured from the curve to POQ, the horizontal line passing through its apex: the supplementary moment of (8, 19) is proportional to the distance VU between the curve and the horizontal line passing through its extremity R. The first of these moments is that which we have denoted by m in the preceding algebraic formulæ: the latter moment is that which determines the strain on the girder, and answers to the numbers on the line S in the two tables previously given.

Since the ordinates of the curve of moments ROS are proportional to m, and since $\frac{dm}{dx}=l$, it follows, that if the tangent VW be drawn to the curve at V, the tangent of the angle (VWU) which VW makes with the horizontal line is proportional to the load from 0 to 8, or to what may be termed the superincumbent load on the point 8.

To put this more plainly. From W, the extremity of the tangent line VW, measure off WX, equal to 10 feet by the horizontal scale, and through X draw an ordinate meeting the tangent line in Y. This ordinate XY will therefore be equal to the tangent of the angle VWU for the radius 10. Apply the length XY to the arbitrary vertical scale of tons by which the curve of moments has been plotted, and the reading will be found to be 170 tons, *i.e.*, ten times the amount of load from 0 to 8. The apex or crown of the curve of moments will of course be at O, in the same vertical line with M, where the elementary moments vanish. Here the tangent will be horizontal, there being no superincumbent load at O. When the rate of loading is uniform, $\frac{d^2m}{dx^2}$ will be a constant, and the curve of moments will therefore be a parabola.

◆

COLOUR AS APPLIED TO ARCHITECTURE.*

By Sydney Smirke, R.A.

In a former lecture I addressed to you some observations on the application of colour to the purposes of internal decoration. I propose now to pursue the subject of colour as applied to architecture, confining, however, my views on the present occasion to its use on the exterior of buildings.

It is very obvious that there is, in many respects, so wide a difference between the requirements and capabilities of external and internal decorative architecture, that very different rules must guide us, and very different circumstances have to be taken into consideration. Within the four walls of a room we can generally command our colours; we need introduce no inconvenient or discordant combinations; and although there may be, and undoubtedly are, various difficulties to contend with, it may be said that they are not insurmountable, inasmuch as the room is at our own command; and if we introduce discords, or otherwise unpleasing effects, it is generally speaking our own fault. But it is not so in the case of exterior architecture,—there the difficulties are real: we have to design the colouring of our building with reference to circumstances over which we have no control whatever. Our building may be required to be placed in juxtaposition with other buildings, or objects already existing, which we may not disturb; or it may be surrounded by natural objects, to which our building must per force, to some extent, be in subjection, or at least on terms of amity and co-operation. Moreover, colour is closely allied to light. Within a room the light is strictly under our control; we can subdue it to any extent; we can render its influence as partial as we may think proper, and cause it to enter the room in whatever direction it may be expedient that it should enter. Quite otherwise it is out of doors. The exterior of our building is exposed to the searching light of day, and the sun's rays will come in whatever way, and with whatever intensity they please, upon the surface of our work. Hence, therefore, it is that we find ourselves compelled to be guided by very different principles in the two cases. It was on this account that the observations which I had the honour to make to you two years ago were expressly, and almost exclusively, confined to the application of colour to the interior of buildings.

I have said that colour is nearly allied to light: hence bright colours seem to harmonise especially with a bright light, and brilliant colours have ever been regarded as congenial to brilliant climates. This remark is no doubt trite; it must have occurred to almost every observant person that most of the productions of nature in those climates where the sun is powerful, are distinguished by more intense colouring than elsewhere. In an ornithological collection we are almost always able to pronounce with some precision whether a bird is a native of an arctic, temperate, or intertropical climate, by applying to it the test afforded by the relative brilliancy of its plumage; and the same would seem to apply to the furs of other animals. We see how colour graduates, from the intense markings on the tiger's back, to the dingy, or even colourless, coverings of the animals living in polar regions. No doubt there are exceptions, but the general prevalence of this apparently fundamental law cannot escape our observation, or be attributable to mere caprice or accident. I would not dwell upon this law of nature did it not appear to me to be well calculated to throw light on the special subject of my present observations.

---

* Lecture delivered at the Royal Academy.

In the regions of the East men's eyes are early educated to the appreciation of colour, by having natural colours constantly before them; whilst amid the grey mists of the North we may, it is true, learn to appreciate colour, but the education must be artificial; and hence perhaps it is, that when we do indulge in colour, we are apt to run into some preternatural, and even painful excesses; and, prompted rather by fashion than by instinctive or natural feeling, our fancy becomes capricious and ill-regulated, rushing from whitewash to polychromatic ebriety. This is not as it should be. If we are not by nature endowed with a delicate perception of the niceties of colour, we should at least learn to understand the principles which regulate it; for colour, like a sharp weapon, needs to be used with that caution and dexterity which knowledge and experience alone can give.

But I am, perhaps, prematurely entering into my subject, before urging on your attention those principles which, I think, should regulate us in our attempts to avail ourselves of those beauties which our art can certainly derive from a judicious and well understood use of colours. Before, I say, we descend into a detailed consideration of those principles, we should, I think, look back cursorily over the works of our predecessors; review the progress of the art of applying colour as a means of exterior architectural decoration, and take a glance at the experience and practice of other times and climates.

In Egypt, the cradle of art, it is beyond dispute that brilliant colouring pervaded their architecture. Egyptian artists used profusely a few positive colours, for they had not learnt to derive pleasure from those niceties which more advanced art delighted in. The uneducated eye, like the eye of a child, is sure to be captivated by brilliant colouring. Hence we might fairly expect, *à priori*, that such would be the character of the colouring adopted among those earlier pioneers of art who peopled the East. I do not think that it will be a profitable or an appropriate topic of inquiry here, to investigate the principles which guided the Egyptian and Assyrian builders, if, indeed, principles they really had to guide them. It seems probable that motives of taste regulated their choice of colours less than certain considerations of a religious character, and these involve archæological inquiries which are quite foreign to our business here.

When, however, we advance to the period of Greek art, we are bound to believe that art (although no doubt still influenced by the traditions of their predecessors in civilisation,) was allowed more freedom, and that the Greek artist sought to gratify the natural good taste of his countrymen, liberated from mere conventional forms, and disregarding prescribed dogmas in the adoption of colour. Unfortunately, time has spared us so few indications of original colour actually existing, that modern artists and art-writers have been tempted by the paucity of ascertained facts to indulge in theories of colour not based on any sound authority, and the somewhat vague and accidental expressions of ancient authors have been called in aid to supply the place of the more exact and satisfactory information to be derived from actual observation.

Without embarrassing ourselves with the very discordant views of the different archæologists who have written on this subject—and the subject of ancient polychromy has indeed been most fruitful of controversy—I will content myself with simply stating the convictions which I have myself arrived at. My own belief is, that the external architecture of the Greeks was enlivened by a considerable amount of strong colour in the details, and that even the broad surfaces were occasionally, perhaps often, stained with fainter tints. That the details were so enlivened we have the undeniable evidence of surviving fragments; and we need go no further than our own national Museum for such evidence. In the Xanthian examples, the late Sir Charles Fellowes has satisfied us that the tombs of early Greek workmanship were profusely painted. Colour was traceable when those remains were first explored, although the climate of this country has perhaps effaced in most cases the indications of it. Nor can it be with truth in all cases asserted that the colours observed might have been the daubing of later and degenerate days; for an example occurs in the British Museum where the soffit panelling has had its enrichments marked in preparatory outline, to be filled in at a future time with colouring, of which some accident seems to have occurred to prevent the completion.

That the general surfaces were stained occasionally, perhaps often, we may infer from certain expressions that have been detected in ancient writers, and from the fact that many of the m[illegible]antic, and some even of the purest examples of Greek architecture, were executed in a coarse limestone, coated over with a thin covering of stucco, the crude whiteness of which would not have been tolerable, and which, therefore, we may very reasonably and safely assume to have been subdued by at least a certain amount of colour. But it by no means necessarily follows that, because colour was in such cases always resorted to, it was therefore habitually applied to all architecture, and that the beautiful crystalline Parian marbles, so highly prized by the Greeks themselves for their purity and transparency, were thus habitually discoloured. Although we know well that early Greek art was greatly influenced by Egyptian and Assyrian practices, leading to what we may now regard as an excessive use of colour, I can with difficulty bring myself to believe that the fine æsthetic sensibility of the Greeks could ever have been reconciled, by any amount of respect for their predecessors in art, to the destruction of the pure translucency, and to the obliteration of the delicate natural tints of their marbles, by painting over the columns and broad surfaces of their buildings with strong opaque reds or blues, as some would wish us to believe. Upon the whole, I should say that the wide diversity of opinion among the writers who have discussed the difficult subject of Greek polychromy, is somewhat disheartening to those who are simply in search of the truth; but perhaps encouraging to those who, whilst reverencing Greek artists, are shocked at the rank colouring attributed to them, and would fain disbelieve that such outrages were ever committed, and hope that they were in their best days more temperate in the use of colour than some of the able advocates of glypto-chromatism* are wont to represent them to have been.

So destructible and evanescent as all artificial and superficial colouring is, it is not to be wondered at that we are as much at a loss for surviving Roman examples of exterior colouring as we are of Greek; but we may very safely assume that the love of ornament and splendour, which especially distinguished Roman imperial art, is more likely to have led to an increased than to a diminished resort to colour on the exterior of their buildings.

It was at this period that the use of marbles of various natural colours dispensed with artificial pigments. Even as early as the date of the Greek remains at Halicarnassus there is strong evidence that the natural diversities of colour in the material were resorted to as a means of giving variety to exterior architecture. That such was the case may be inferred from the fact, that the blocks of marble recently obtained in great abundance by Mr. Newton, from the ruins of Halicarnassus, differ considerably in colour; some are as pure and as white as the Parian itself, other blocks are of a dark slate colour, and there are various intermediate hues. How these variously-coloured marbles were arranged with reference to each other it may now be very difficult to ascertain, but the effect that would unavoidably result from using them indiscriminately would be so bad, that it is not to be supposed that any Greek artists could have so employed them; and we are thus inevitably led to the conclusion that the arrangement of these light and dark coloured marbles was probably made in conformity with some principle or method adapted to impart variety of effect to the architecture.

At Rome, so great became the passion for coloured marbles, that Ovid says, "Decrescunt effosso marmore montes;" and artificial processes therefore for staining marbles were adopted for the sake of giving them a more ornamental character, processes which lapidaries of the present day are known to practise. Indeed, the use of coloured marbles became so universal, that Pliny seems to hint that the known available sources of ornamental marble were becoming exhausted; and to this he attributes the invention of marbling, although it seems more likely that this fictitious splendour was one of the significant signs of the decay of taste in the empire. It was at this period also that the practice of veneering stone and brick with thin laminæ of marble took its rise. In the portico of Octavia, in Rome, I observed the exterior face of the brickwork lined with slabs of marble, scarcely two inches thick; but at the great theatre in Taormina, in Sicily, I found marble veneering executed with really wonderful dexterity, the thickness being scarcely more than that of ordinary card. The dexterity, indeed, which this veneering required in its execution affords strong ground of presumption that the practice was common.

---

* I have been reprimanded since the delivery of the lecture, by a very distinguished art-scholar, for coining this word. I may perhaps have been misled by Bavarian authority into using this term, for which (in deference to him) I would substitute αγαλματοχρωσις, or "statue-colouring."—S. S.

In what way and to what extent the architecture of the later Roman empire was affected by the contemporary style of design prevalent in the East, is a question of undoubted interest, but it is one upon which those who have treated on the subject seem to entertain by no means clear views, a difficulty arising perhaps in a great measure from the uncertainty that hangs over the dates of early Eastern buildings. But it would hardly be germane to the subject of these lectures to enter into inquiries so exclusively historical. It may suffice to say that, either through the fusion of the decaying Classic style with some other style that may have pre-existed, owing its origin to Oriental artists, or through the direct changes effected in the Roman manner, when the task of building fell into the hands of the predominant races of the East, even without assuming the influence of any pre-existing style, certain it is, that a very readily distinguishable change took place: and one of the most marked characteristics of that change was the extended application of colour to architecture. Tho use of mosiac work is especially a marked feature in this new phase of art. Although this work was the invention of an earlier age, and was very largely used by the Roman architects in pavements, I am not aware of any evidence of the application of this species of work being applied as a mural decoration in any building of positively Classic date, and I presume that this latter use of it may be confidently regarded as originating in the Byzantine school. The practice of inlaying and panelling marbles as an incrustation on the surface of walls is also another very prevalent mode of ornamentation marking the the period; much resorted to, no doubt, by the Romans even in the best periods of the empire, but received in the Byzantine school with particular favour, from the facilities it afforded of coloured enrichment, in which that school, as we have seen, so greatly excelled.

I need not remind you that Byzantium, during the least cultivated periods of European history, was the sole asylum of the arts, and it was thence that the earliest rays of a revival dawned on Western Europe. Italy, Sicily, and Spain, were the first countries to catch these rays. Hence it is that we there find the earliest developments of this new feature of architectural ornament. The new buildings of Venice and Pisa became resplendent with coloured marbles, both internally and externally applied. Then, too, arose that parti-coloured system of decoration which, in our ceaseless aspirations after some new beauty, has of late found some favour in our eyes. The Duomo at Venice is a very early and remarkable adaptation of coloured materials to external architecture. The shafts of the small pillars are of various coloured marbles, whilst incrustation of porphyry and other precious materials of like nature enrich the surface of many parts of the building. Florence affords many notable examples; and in Giotto's celebrated campanile the practice of panelling and otherwise intermixing variously-coloured stones was extensively adopted, and treated with admirable taste and skill. Indeed, throughout this period of Mediæval architecture in Italy the practice prevailed of building in courses of coloured masonry, and it became, in truth, a characteristic feature in the buildings of that age in Italy. Doubtless, these alternating courses of coloured stones came to Italy from the East, for they have there been a passion, originating perhaps in the deep-seated love of colour which marks Oriental taste. There is no denying the extremely pleasing effect of many of the Mohammedan buildings so ornamented, and it affords a striking instance of the simple means by which beauty may be attained. Whether the motive was purely æsthetic, or whether the occasional course of coloured stonework had their origin to any extent in some constructive requirements, we have, perhaps, now no means of determining. The latter supposition seems not altogether improbable, at least in Italy. The green marble from Polcevera, in the north of Italy, is an extremely hard substance, and the occasional introduction of courses of it, properly cramped together, would no doubt form a useful tie, and contribute much to the stability of a wall. It is however to be remarked, that even in Italy this mode of construction was only of local prevalence. It is far more frequent in the north and middle of that peninsula than in the south. Instances in other parts of Europe are comparatively more rare; and as far as my knowledge extends, very few instances of regularly banded or striped masonry, where different coloured stones are used in alternating courses, occur in our own country.

The nearest approach to external polychromy in England, is perhaps the intermixture of ashlared stone and square flints, which occurs so frequently in the ecclesiastical architecture of the eastern counties, and by which a pleasing variety of tone, if not of colour, is often produced. There is no reason to believe that external colouring, whether by the use of naturally coloured materials or by superficial painting, was ever extensively practised in this country during the best periods of Mediæval art. Perhaps the most usual application of the practice was in the shafts of columns; a blank spandril or gable was occasionally relieved by a coloured panel, but this occurs rarely, sculpture being ever considered as the readiest resource whenever a blank space is to be lightened or an enhancement of the effect is desired. But probably in no country on the Continent has the mode of producing a rich effect of colour by the use of bricks and stone intermixed been better understood, or more effectively carried out, than in England during the Tudor period. In the wide alluvial tracts of Germany, where the use of bricks was earlier introduced than in England, quite as widely disseminated, and as generally practised, I have not myself seen, nor have I been able to ascertain that others have met with, that regular and systematic use of the interlaced courses of dark bricks on a red brick ground with which we in England are so familiar, and which so admirably attains the object of relieving a plain surface of wall without labour or effort, at the same time lowering and qualifying the general tone of colour in a highly picturesque manner.

It is not unworthy of note that at a period when in England we were thus struggling to relieve the monotony of red bricks, our more advanced and ingenious contemporaries in Italy were stuccoing the surfaces of their palaces to receive fresco paintings, and often employing the very highest available art upon the plain surfaces so obtained. Vasari relates many instances of this employment of the painter's art; and it seems highly illustrative of the universal prevalence of a taste for painting in that country when we find men like Perino del Vaga, Garofolo, Gherardi, Bramante, and very many others I might name, zealously engaged in painting historical subjects on a colossal scale upon the exterior surfaces of ordinary street architecture. They could not but have been perfectly conscious of the perishable nature of their workmanship, but it was enough for them that the all-prevailing admiration for art was gratified, whilst they found a wide scope for the exercise of their fertile invention and for the display of their admirable powers.

You are no doubt well aware of the great efforts that have for some time past been made in Germany to revive this mode of exterior decoration. The whole façade of the newly erected picture gallery at Munich is converted into one vast historical picture; the figures are so colossal that in order to appreciate them one needs to retire to the remotest distance that the surrounding buildings will admit of. That veracious geographer, Leno Gulliver tells us of a book he met with in his travels so large that he had to erect a scaffold in front of it to read its pages. So in this truly great work at Munich, we have to take a considerable walk in order to examine the opposite limits of the picture.

But without reference to such extreme cases, I leave it for those who practise the sister art to determine how far historical painting is rightly applied as a mural decoration in the open air. I am disposed to think that the practice will not spread very widely. It seems to me calculated to lead to the degradation of art, for what artist is there—at least in these degenerate days, and in the inclement atmosphere of Northern Europe—who would not feel the warmth of his genius chilled by the reflection that his works could expect only an ephemeral celebrity. Exposed to the vicissitudes of climate, such work could hardly live to be fully appreciated before it must perish. Such certainly has been the fate of nearly all, if not of all, the external frescoes of the great masters of the fifteenth and sixteenth centuries. But so great was the wealth of genius in the palmy days of Italian art, that painters were willing to waste their brightest thoughts, and bestow the exquisite products of their art, on the mere pageants of a day.

But somewhat before the bright period I have referred to, the love of coloured architecture in Italy had found another and more legitimate development. In the fifteenth century was introduced, originally derived no doubt from the East, a new manufacture, by which a far greater permanency could be imparted to colours. In the alluvial plains of Italy arose a passion for glazed terra-cotta work, and in this instance also the most gifted artists did not disdain to impart the Promethean touch of their genius to these fictile productions. Passero, a learned historian of this art, gives 1393 as the date of its introduction, and the eminent names of Della Robbia, and even Raffaelle, are identified with its cultivation. Though limited at first to small fictile works, such as tazzæ, ewers, and the like, it was not long before artists found that the art was applicable to the nobler purposes of architecture. Friezes, panels, and many of the minor features of architectural composition, were thus enriched by colours of the most durable nature. There are, in fact, few substances less perishable and less liable to injury from chemical and atmospheric action than the vitreous glaze on this terra-cotta work. There are many interesting specimens of glazed Fayence ware of a green colour among the Assyrian remains in the British Museum. Those from the north-west palace at Nimrud, and from Konyunjik, date, according to the trustworthy authority of Mr. Birch, as far back as the year 750 B.C. There are also many examples of glazed ware from Babylonia: especially I would name the glazed coffins from Warku; these Mr. Birch is inclined to assign to the days of Nebuchadnezzar. You will find none of these specimens materially affected, except by external violence.

The Italian artists of the Quatro-cento period highly appreciated this material, and used it in their buildings with admirable effect, as at Alberti's Church, at Rimini, and elsewhere. Its application however declined in the sixteenth century; a fact perhaps mainly attributable to the more general and closer adherence to Classical forms, which did not lend themselves so readily to terra-cotta as to stone. Much also may be ascribed to the introduction at that period of external stucco-work.

Coloured terra-cotta never attained to much favour in this country. We see some few examples of glazed earthenware in heraldic shields and other details on the exterior of Wolsey's portion of Hampton Court Palace, and a few other scattered examples may be met with; but it would appear that the gloominess of our English climate, and the noxious influence of our smoke, are not favourable to the cultivation of taste for external coloured decorations, and cause timidity in its application. I would by no means advocate an extravagant use of this vitreous manufacture: such excess would be as little in keeping with the grave and sober character of the English on the subject of art, as it would be unsuitable to our climate; yet glazed and coloured terra-cotta work deserves the attention of every English architect. Its remarkable permanence is a most valuable quality, and its capability of resisting the disfiguring effects of soot seems strongly to recommend it to favour in our larger towns.

Reverting now to the brilliant Quatro-cento period of Italy, from whence I had deviated in order to sketch the progress of terra-cotta as a building material, I should remind you that it was not only in the use of this artificial material that the love of colour in architecture showed itself in Italy. The use in the time of Giotto, and still earlier, of coloured marbles in the enrichments of external architecture, to which I have already adverted, seems to have revived in the fifteenth century, and especially in the north of Italy. In Venice we find few buildings of that period which are not characterised by a profusion of coloured marble panels, friezes, medallions, and the like. Neglect and exposure have contributed seriously to efface these beautiful decorations, but enough remains to enable us to form some conception of the gorgeous effect of the Canal Grande and of the Piazza di St. Marco in the fifteenth century, adorned as they were by the fresh glow of colours in the stately structures then newly erected, as well as by the more subdued embellishments of the rich marbles, mosaics, and tessellations of the earlier buildings of that city. When we recall to our imagination those gorgeous buildings, enlivened as they were by the rich costumes which figure in the paintings of Giorgione and Veronese, the brocaded hangings, the gay standards, and gilded metal-work which must have then everywhere met the eye,—I believe that we shall all admit, without a doubt, that no city in the world, at any period of its history, ever offered such a sumptuous feast of colour as Venice in those her palmiest days.

No doubt many of these marble insertions were the spoils of war in the East; for specimens of the deep red granite and other precious materials may be found among them, which are not known to occur in any European locality; so that, as in ancient Rome, the pride of conquest mixed with the æsthetic predilections of Venetian artists, conduced to promote the use of colour in their architecture. These panellings, however, gradually fell into disuse in the progress of art. More strictly architectual forms came to prevail, and columnar architecture becoming almost universal, the opportunities for the use of coloured marbles became necessarily restricted to the friezes of entablatures and shafts of columns; even this soon ceased to be common in exterior works.

It cannot be denied that there is in the nature of most coloured marbles an inherent defect, which may have largely contributed to bring it into disuse in situations exposed to the external atmosphere. The colours of most marbles depend for their depth of tone and richness of effect on their polish; and that polish is sure, sooner or later, to be destroyed by exposure to damp air. This is not the case with respect to granite, of which silex forms so large a component part, nor perhaps to serpentine; but the polished surface of probably no limestone, however compact and however crystallised, will long resist the effects of exposure.

I have now, in a slight, hasty, and somewhat disjointed manner, sketched the history of the use of coloured materials in exterior architecture. It remains for me now to consider the principles which I think should guide us in their use. This consideration is an important one at the present day, for a fashion—I might almost say a passion—is growing up among us for indulging in this kind of embellishment.

Of all novelties, especially in matters that come within the dominion of taste, the tendency is to degenerate into extravagance and excess. A speculative chemist or an inventive manufacturer has no sooner devised some new modification of colour, than the world of fashion becomes steeped in the favourite dye, till our eyes are tired of the novelty. The leaders of *ton* in the fourteenth century bethought them to prolong the toes of their shoes to an inordinate length: the servile crowd of imitators followed: the passion grew with the growth of this superfluous appendage, till we find that by the middle of that century the toes of any well-dressed gentleman were tied up to his waistband. Again, some unsightly excrescence is supposed to have suggested to the *coiffeur* of Louis XIV. a structure of artificial locks, and not many years had elapsed after its adoption before the heads and shoulders of all Christendom were oppressed by the superabundant load of adscititious hair.

It seems an instinct of the human mind when a new enjoyment or fresh object of admiration is found, to exceed the limits of moderation in the indulgence of it. Whitewashing was once a passion, especially among churchwardens: and the rigid saints and painted purgatories with which it had pleased our ancestors before the Reformation to cover their walls, for the moral improvement of a staring but unreading generation, all became obliterated by the clerical wash of lime-white; and the facility with which that dazzling production could be yearly renewed, and the economical cleanliness which it introduced, seemed to favour its perpetuation; but whitewash had its long day, and lost its hold on the public favour: and there is every prospect that we are now about to enter upon the reign of intense polychromatism.

It behoves us, therefore, to be very careful that this newfledged zeal shall be kept, more especially in the exterior of our buildings, within a just and reasonable restraint. Let us not lose sight of the principles that should guide us, and let us be guarded in the application of those principles: remembering well how often the worst of all things is the corruption of the best, and that the idol of yesterday is the laughing-stock of to-day. I will not say with the ancients, that nothing is permanent but mediocrity, but I am convinced that the most lasting praise is reserved for those only, whether architects or artists generally, who will not risk their reputation by extravagant flights of fancy, either in design, composition, or decoration.

(*To be concluded in our next.*)

THE PRESERVATION OF STONE.

Since the article was written upon the preservation of stone which appeared in our number for February, several evenings have been devoted by the Royal Institute of British Architects to a discussion on this important subject, in which discussion some of our most eminent architects and chemists took part, and a digest of which will be found in another part of this month's number. We find the opinions we have already advanced mainly corroborated and proved by the experiences of those who assisted at this discussion, not one of whom (although they might entertain an opinion more in favour of one process than another) would recommend, on their own responsibility, any particular one for adoption, with the least hope of its proving permanently successful. The processes at present known as preservative processes are to be divided into three classes; each of these had their representative at the discussion.

The first, the Bituminous, may be said to have received its *coup-de-tête* from all, more or less, on account of its colour. We agree with the verdict, though we differ in the judge's charge to the jury, since bituminous matters have learned to put off their universal mourning under some important circumstances.

The second, the Oleaginous, may equally be said to have received its *coup-de-grace;* and from the fact having been fully proved that all such substances fall victims to the decomposing effect of oxidation by the atmospheric air, materially increased by sun and rain, we trust no one will attempt its resuscitation.

There then remains the Siliceous, under which head, differing from Mr. Tite, we must class both M. Szerelmey's and Mr. Ransome's, with a few words of explanation for so doing. Penetrating the halo of romance enveloping M. Szerelmey's secret, we learn sufficient for our purpose to know that the specification read by Mr. Tite, which caused (from the details of its extraordinary and sanguinary composition) so much merriment amongst the audience, is by no means the exponent of the system used on the Houses of Parliament, which system is as follows (leaving the secret of the materials, so far as the inventor's choice of them, in his own hands):—A soluble silicate is first applied to the stone to be preserved; this is followed by a coating of calcareous matter, bound by some animal glue or size. This second coating it is intended shall, in process of time, form a hard and insoluble coating by combining with the first on the stone; but in order to fix it there for the period necessary to this change, it must have a protective medium of an oleaginous or bituminous character. The outcry against all substances of the first-named class evidently induced M. Szerelmey to make a change, and thus the difference between his first and later specimens to be seen at the Houses of Parliament, and which are so unsuccessful. The first specimens retained a considerable amount of hardness until the protective coating of oily matter became oxidized, when not only the protector, but that which was to have been protected, became easily removable in clouds of dust. The later specimens are and have been more or less soluble from the first, as may be proved by attrition with the aid of water, and therefore are still more unstable than those preceding them. Still, failure as it has proved, we agree entirely with Prof. Hofmann that there is more truth in this theory than the silicate of lime process of Mr. Ransome. That eminent chemist remarks, that if Mr. Ransome deposits a silicate of lime in the pores of the stone, or upon the stone, it has no affinity for, or power of combining with the silicate of lime or magnesia of which the stone consists, but is indeed an inert mass, filling up the outer interstices of the stone with a powdery substance, easily removed by time or attrition. Much has been said about the crystallising properties of the precipitate formed by the calcium and silicate; but we would suggest that the precipitate is not crystalline itself, and would never become such, from the fact of its consisting largely of free lime very loosely held, indeed forming to a great extent a mere agglomeration of substances with little or no chemical union. Let anyone doubting our assertion, and believing this precipitate to be a chemical union of silica and lime, treat the precipitate with acetic acid, dissolving out the lime in the form of acetate of lime, the presence of which lime in large bulk in the solution may be detected by a drop or two of sulphuric acid throwing down a bulky precipitate of the sulphate of lime, better known as gypsum.

Thus then, after all that has been said about this silicate of lime and its crystalline and crystallising properties, we find it to be in effect a loosely combined mechanical mixture of silica (or at the most a double silicate) and lime. This however does not account for the extraordinarily rapid decay exhibited by the specimens in the Houses of Parliament or the Institution of Civil Engineers at Westminster, which we think may arise from an acidity in the chloride of calcium used. An impure chloride of calcium may be obtained at about 2*d.* per gallon, as made from a waste product consisting of the lime scrubbers that collect the chlorine evolved in the manufacture of soda, which lump of lime (or scrubbers) also collects a large amount of hydrochloric acid, the caustic properties of which are well known to be most disintegrating. The purer kinds of fused calcium, not to speak of the pure chloride, are so much more expensive that there may be an inducement to avoid the extra cost. The waste product has however the great drawback we have named to set off against its extreme cheapness, which certainly promised well in a commercial point of view. Prof. Hofmann has made a most scientific and ingenious suggestion in proposing the use of silicic ether. We much fear the cost of this material will preclude its adoption on anything like a utilitarian scale; for we must not forget the thousands of edifices that are in the same need as our Houses of Legislature, and whose owners only await the result of this important precedent.

One fact has however been unquestionably proved, viz., that no existing process is worthy of adoption. The next point for consideration is how far any of them may, from the experience we have gained, and the extra consideration we have been led to bestow upon the subject, influence our success in directing us in future research. To some extent the discussion has already shown a favourable influence; and the remarks we have made are not to be taken merely as condemnatory of systems fully proved abortive, but rather for the purpose of rendering them and the causes of failure better understood.

◆

THE PHOTOGRAPHIC SOCIETY'S EXHIBITION, PALL MALL EAST.

Any well-selected collection of photographs possesses intrinsic materials which must attract notice, but beyond this, in respect to the art itself, we have now arrived at a stage from which greater things can hardly at present be anticipated. Viewed in this light, the eighth exhibition of the Photographic Society is a good one, perhaps beyond the the mark of previous years, but yet presenting no very striking novelty or fresh development of science that we can detect. The most important picture is (30) a view of the Coliseum at Rome, produced by collodion, the photographer being P. Dovizielli, who also exhibits the "Aurora," after Guido (40), and St. Peter's at Rome (52). There are some exquisite landscapes by Fenton, Lyte, Pumphrey, and others, including F. Bedford, whose architectural gems, as usual, bear the palm. His "Excavations at Wroxeter" (Uriconium), (41, 43) will be examined with great interest. Mr. Dixon Piper, whose excellent photographs of Suffolk buildings we have on former occasions referred to, contributes several of these to the present exhibition, as do Messrs. Bisson of Continental subjects. Mr. Baynham Jones has two views of Raglan Castle (32, 34) which may be examined in comparison with those by Mr. Bedford, Mr. Mudd, and Mr. Dunn. Capt. Verschoyle has a frame (137) containing nine interesting subjects, including Glastonbury, Wells, and Launceston Church. Messrs. Cundall and Downes send some good architectural bits—such as (234), Bishop Fox's tomb, Winchester Cathedral; (248) the Hospital of St. Cross, near Winchester, and several others from the same neighbourhood. Several Indian structures, which have been well photographed by Capt. H. Dixon, will be found on the first screen (399—410), while on the third screen will be observed some charming landscape groups from the Cheddar Cliffs (475) by Bedford, and two from North Devon (481) by the same artist. There are in all upwards of 600 pictures.

◆

ON FELLAH ARAB ARCHITECTURE IN EGYPT.*

By Professor Donaldson.

It will be remembered that when Champollion and the other investigators of the hieroglyphic inscription on the famous Rosetta stone, had their inquiries so materially aided by the Greek translation of the edict on that trilingual slab, they had still to find the elements of a language embodied in the hieroglyphic and demotic character, so as to afford a clue to the hidden meaning. With much ingenuity reference was made to the tongue of the people who had constantly inhabited the country, and among whom tradition might still have retained the like language. Success attended this reference to the Coptic, which was found to contain the key of the ancient Egyptian language.

As I was travelling in Lower Egypt I was struck with the fact that almost all the villages are built on artificial mounds, rising from 20 feet to even 100 feet and more, above the general flat and level of the natural soil. These mounds abound in the neighbourhood of Alexandria and Cairo, and in the valley of the Nile; and, in fact, throughout Lower Egypt; consisting of accumulations of the Nile mud, mixed up with large quantities of fragments of pottery. If for any reason portions are cut through or removed, all sorts of antiquities,—as for instance, bronzes, terra-cottas, scarabei, and even tombs with mummies—are occasionally found, as also sarcophagi. At length I found them to be the sites of ancient towns and villages of the remotest periods of known history,—accumulations of a succession of generations, which had had their frail tenements built one over the other, thus raising the mass still higher. They were thus more and more above the influence of the annual risings of the Nile waters, and protected from ravages that were caused thereby; and the more healthy as they were higher above the occasional miasma arising from the vegetable decomposition, the natural result of the stagnation of the waters, until the Nile retired within the limits of its natural bed. Having to go to Ras-el-Wadi, in the valley of Goshen, I saw the grand and extensive mound of Bubastis, of high note in ancient times, and situate near Zagasik: it rose from the plain like the mounds of Nineveh, Nimrud, and other Assyrian cities described by Layard, and with which these Egyptian mounds have a remarkable analogy. I was detained for some hours on two occasions at Benha-el-Assal, on the Damietta branch of the Nile, close to the mound of the ancient Athribis, where a friend of mine has found a great variety of antiquities. I was struck with the rude form of the mud-built huts and houses of the fellahs, or people of the country. The walls consisted of sun-dried bricks, of a dusky brown colour; the faces inclined backwards, like the ancient Egyptian temples; flat terraces formed the roofs, on which the Arabs stow their fuel, and perform many of their domestic operations. The apertures for light or air are of rare occurrence, and small, seldom appear on the outside, and are more generally next the court, to insure privacy and shade. While I was detained at the railway station of Benha I made it a point of thoroughly examining its adjoining village; and calling to mind the representations of domestic buildings which we have upon the hieroglyphics and frescoes of antique Egyptian monuments, and as given by Sir Gardner Wilkinson, Champollion, Rosellini, Lepsius, and in the work of 'L'Egypte,' I recognised the analogy at once between ancient and modern usages, and found that the buildings, like the language of the people, are a tradition of bygone times of remote antiquity; and that the one explained the other, like the modern cottages of Lycia, which present the same features of timber construction as the tombs of Zanthus, carved 2000 years ago. The bricks are nearly about the same size as ours: they are simply made of the Nile mud by boys, who perform all the operation, assisted by girls and other boys, who carry the material to the modellers, each of whom makes 900 per diem in winter, and 1200 in summer. They are placed with two courses of stretchers to one of headers. The wider openings have timber lintels of the date-wood. To produce an ornamental appearance, they lay a line of bricks herring-bone fashion, so as to present a sharp edge on the face. At others, every alternate header recedes from the face 2 or 3 inches. They have tile-formed bricks, about 12 inches long by some 2 inches thick, to form pointed tops to small apertures, or ranged in a row to give a zigzag appearance. Vertical channels are sometimes introduced, like those in the face of the ancient propylæa, for the banner-masts, and they are formed either by receding bricks one over the other, or by vertical bricks placed edge on one over the other. Over the doorway I observed that they always had a bit of crockery, as a plate, inserted into the face of the brickwork: one of those I saw was a plate or dish with the willow pattern on it. Frequently the doors are painted in brilliant colours, especially green, red, and yellow, with white, in patterns; and I should observe that at Cairo, every hadji who had been to Medina or Mecca immediately had his doorway bedizened with colour, to mark the important event. The general tone of the houses and villages is a dirty mud, now and then, yet very rarely, enlivened with a little whitewash on the strings and other features. But the mosques are always white.

---

* From a paper read at the Royal Institute of British Architects.

The streets of the villages are very narrow, varying from 4 or 5 feet to 7 or 8 feet, except perhaps one or two streets for the bazaar, which may be 10 feet wide. This is for the purpose of shade, and keeping the streets cool—a necessary precaution in hot climates, and very prevalent in the East. The huts are only one story high, and rise 7 or 8 feet. Some houses have two stories, and a courtyard, with an outer staircase leading to the upper rooms. At the village of Saccara, the treads or steps of a house at which I slept consisted of blocks of Thorah stone, brought from the ruins of the adjoining tombs and pyramids, carved with hieroglyphic inscriptions on the upper face, and which were being gradually worn away. The floors and roofs are formed of rough lengths of the palm-tree wood, some 12 inches apart, covered with reeds and a thick coating of mud, which cracks easily, and admits the rain whenever there is a storm; this, however, is of rare occurrence above Alexandria, though frequent enough in that town.

The Arabs pay great attention to ventilation, and have apertures expressly for the purpose over the doors and windows, and under the ceilings in other parts, and occasionally just above the floor. These apertures they close with a mat stuffed in, which they remove whenever they wish to produce circulation of air in their cabins or rooms. Their sanitary precautions extend no further, for they have no drains, and all their dwellings are very dirty, and abound in fleas, not to mention other insects and vermin.

As I passed along the Egyptian plains and valleys, and saw these mounds, one after the other, with flat-roofed buildings and of pyramidal shape, I could not but feel impressed with the conviction that these modern constructions recall the features of the towns and villages of antiquity erected on the very site of olden cities,—inhabited by a like race, ruled by like laws of supreme power in their chiefs, following the like customs, but destitute of that civilisation and grandeur of conception in their priesthood and dynasties which once produced those wondrous fabrics which have employed the highest genius and most profound learning of modern times to investigate their ruins, and read the hidden mysteries of their records still preserved.

◆

CHURCH OF ST. JOHN THE EVANGELIST, HOUSHAM, YORKSHIRE.

(*With an Engraving.*)

This church, of which we give an exterior view, has recently been completed. The arrangement of the plan is excellent and novel, and admits of great internal comfort in the nave, and of good architectural effect externally. The plan comprises a chancel 29 feet by 15 feet, with a round-ended apsidal sanctuary, having a vestry in its north-west side, the organ being placed under the archway leading thereto. The nave is 41 feet by 21 feet, with a porch and turret at the west end, as shown in our illustration. A low stone screen separates the nave from the chancel. The altar is placed at the extreme east end of the apse. The pulpit, which is inlaid with various coloured marbles, is situated at the north-east end of the nave. The font is at the west end. The window tracery, of Geometrical Middle Pointed design, is excellent.

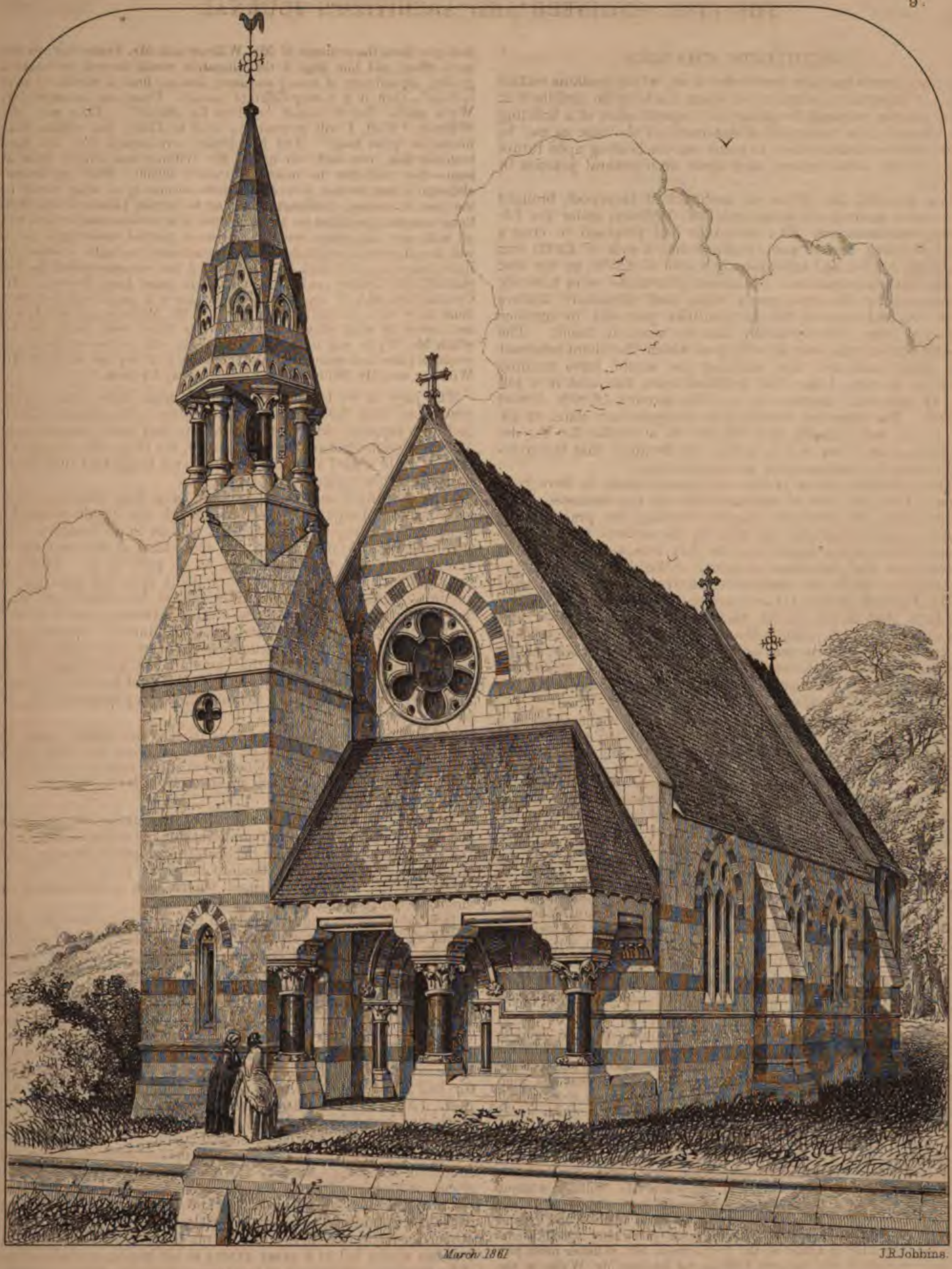
The masonry is of white stone with red bands at intervals, and the internal face of the walls is finished precisely in the same manner as the outside, having also red bands. The roof is of the circular-cradle form. The floors are tiled throughout; and the seats in the nave are all movable. The chancel arch, which is continuous at the impost, is cinque-foliated. The apse windows are combined by a foliated arcade of hood-mouldings, sustained on detached marble shafts. The reredos is composed of three circles, the centre one being filled by a cross; the side ones are foliated, and all are inlaid with marble; a rich band of foliage running around the upper parts of the circles, which are separated by small marble shafts. The sacrarium is boarded on the underside of the rafters, and is very richly painted. Some of the windows are filled with stained glass of excellent design, by Messrs. Clayton and Bell. The following are among the subjects:—

In the chancel.—North-east window—1. The Last Supper; 2. The Agony in the Garden. Centre window—1. The Crucifixion; 2. The Descent from the Cross. South east window—1. The Entombment; 2. The Resurrection. In the south window—The Six Acts of Mercy.

In the western sexfoil—Our Lord surrounded by Angels.

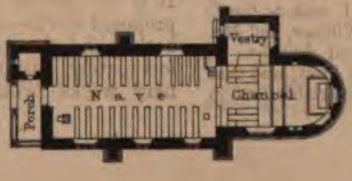
In a three-light window on south side of nave are the following —1. Naaman washed in the Jordan; 2. The Baptism of Our Lord. 3. St. Philip Baptizing the Eunuch.

The church was erected at the sole expense of Mrs. Cholmely, of Housham Hall, from the designs and under the superintendence of Mr. George Edmund Street, architect, London.



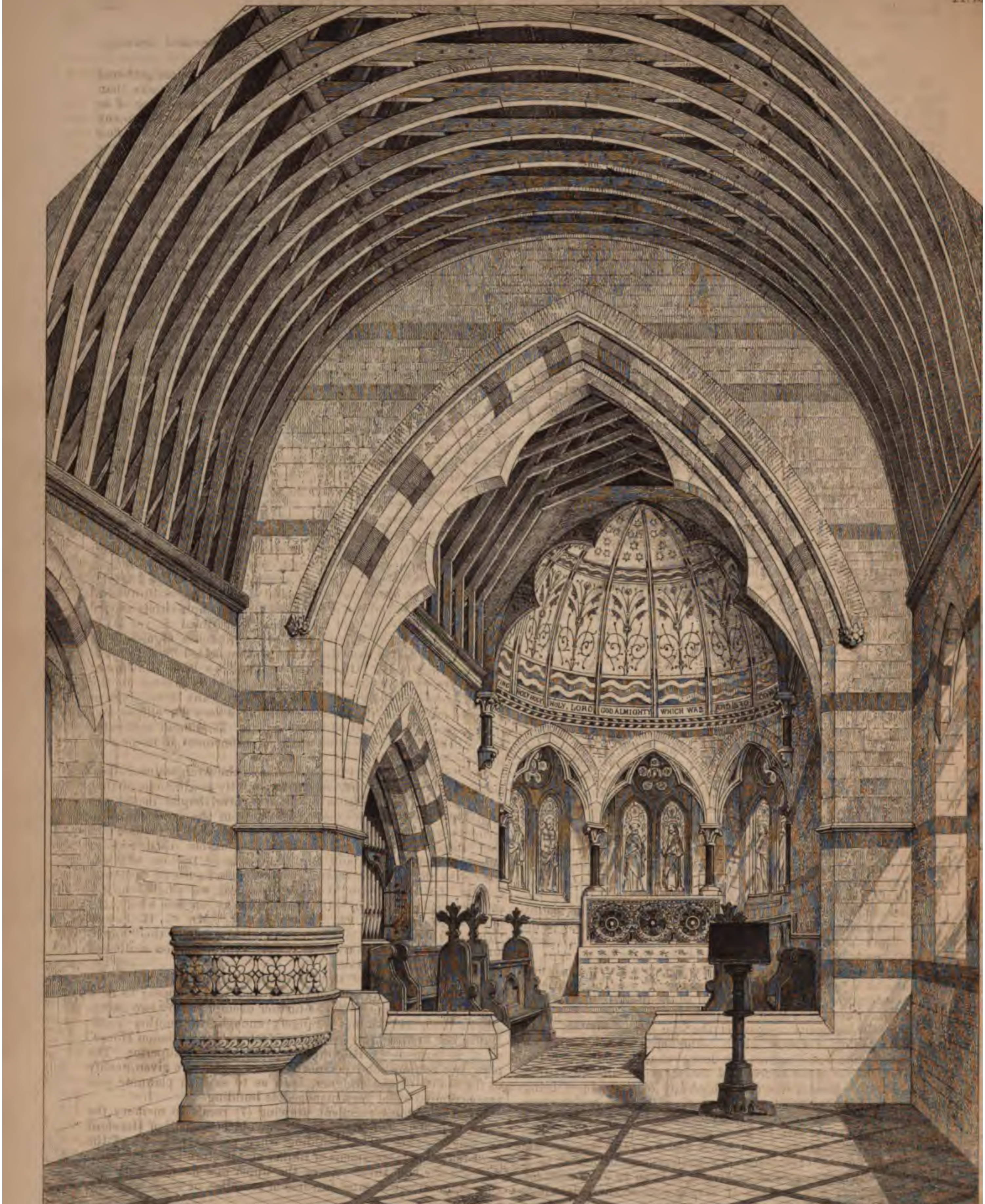
March 1861

J.R.Jobbins.



CHURCH OF ST JOHN THE EVANGELIST
HOWSHAM YORKSHIRE

G.E. STREET, ARCHT



J.R.Jobbins

INTERIOR VIEW OF THE
CHURCH OF ST JOHN THE EVANGELIST, HOWSHAM, YORKSHIRE.

ON THE PRESENT CONDITION OF THE WATER SUPPLY OF LONDON.*

By George R. Burnell, C.E., F.G.S., F.S.A.

A few years since public attention was called, in a very prominent manner, to the numerous questions connected with the quality and the mode of distribution of water in the metropolis, and a very expensive parliamentary contest was waged between the advocates of the existing companies on the one side, and the General Board of Health on the other, which for a time clothed the whole subject with interest. After the excitement of the contest had passed away, the public interest seemed to have subsided; and at the present day the London population is contented to enjoy the advantages of the water supply it possesses, without much inquiry into the means and agencies employed in securing that blessing. Nevertheless the subject is one of sufficient importance to merit an occasional review; and as some very able persons connected with the administration of the laws affecting the public health have felt called upon to make what may be considered to be accusations against the quality of the London water supply, it has seemed to me desirable to bring about, if possible, an open discussion as to the merits and demerits of the present water supply, and as to the feasibility of some of the schemes proposed to remedy its defects. In some cases the operations of the waterworks companies, subsequently to the passing of the act of 1852, have also raised questions of the highest interest with respect to the subterranean geology of London, which I think merit more attention than they have yet received, and it will be my object briefly to allude to the conclusions fairly to be drawn from the facts observed with respect to them.

London, as is well known, is built in the centre of a large basin of the tertiary formations, composed mainly of stiff blue clays, underlying occasional patches of sands and gravels, and consisting at its base of permeable sand and mottled clays. The basement beds rest upon a depressed surface of chalk; and if, for the present, we limit our survey to the superficial geology, we find that around the lower margin of the chalk the subcretaceous formations outcrop in the valley of the Thames, to be succeeded by the oolites, and that none of the affluents of that river flow from any of the strata older than the oolites. All these formations, it is important to observe, are more or less of a movable character, and their materials can easily be disturbed by heavy rains; moreover, nearly the whole of the surface of the valleys of the Thames and of its affluents is under cultivation, and is therefore the more susceptible of such disturbing actions. Lechlade, the first point where the navigation of the small head-streams of the Thames commences, is situated at about 146 miles from London, and at an elevation of 258 feet above low-water mark of London-bridge. From thence the river, called in this part of its course the Isis, receives the Evenlode and the Churwell, flowing from the oolite and lias groups; then below Oxford it receives the Thame, also from the oolite, and Oxford clay; the Windrush and the Ock, from the chalk or from the subcretaceous deposits; at Reading it receives the Kennet, from the chalk; at Maidenhead, the Lodden, from the London clay; at Staines, the Colne, from the chalk; at Ham, the Wey, from the green sand under the chalk and the chalk itself; and shortly beyond the junction of the Mole, the tide is shut out by means of the Teddington locks. There are a few insignificant streams supplied to the Thames by the Bagshot sands, and, as we have seen, a few streams are derived from the lower green sands; but nearly all the affluents and the main stream are supplied by the formations which are likely to communicate to water the bi-carbonate of lime; and from their high state of cultivation, and the number of inhabitants on their banks, it is fair to suppose that they also contain a rather large portion of organic matter. These remarks might be extended to the water of the Lea and of the Ravensbourne, for they are both fed principally from the chalk springs of their respective valleys, and from the surface drainage of their water-sheds, which are, as in the case of the valley of the Thames, highly cultivated. The only geological formations of a nature to supply pure soft water, in sufficient quantities for the consumption and the waste of a town like London, are situated at a very great distance from it. The Bala Lake, to which it has been proposed to resort, is, in fact, situated at about 170 miles as the crow flies; nor are there any large bodies of water of a similar character to it to be met with nearer the metropolis, nor are any of the primary or plutonic rocks to be found within a reasonable distance.

In addition to the sources of water supply provided by the river and its affluents, the inhabitants of London were able formerly to derive a large quantity of water from shallow wells, sunk in the superficial gravels, or from the deep wells sunk into the sand beds of the London clay, or into the subjacent chalk. For all municipal purposes, the wells in the gravel have long since become useless, and both on the score of the quantity and the quality of their water, they may be here passed over, especially as the recent inquiries with respect to the effect of their water upon the diffusion of the cholera have raised so strong a feeling against their use, that no one would dare now to recommend those fluids for any other purpose than for filling such pieces of ornamental water as the Serpentine, or St. James's-park. The deep wells in the basement bed still yield large quantities of water in some parts of London, and they are of great local value to manufacturers; but in other parts of the hydrographical basin of the metropolis, in consequence of the existence of a series of upheavals and displacements, the supply to the underground beds is so intercepted, and at the same time so great is the demand upon them, that even in the most favourable places they are gradually becoming exhausted. In the works of Messrs. Prestwich, Mylne, Braithwaite, Clutterbuck, &c., will be found a great mass of information on the subject of the gradual exhaustion of the subterranean water-bearing strata of London; and the permanent depression of the water-level in them has actually become an evil of serious practical magnitude to the factories which rely on this source of supply. It seems, however, that as much as 20,000,000 gallons per day are still drawn from the various wells about London, but now principally from the chalk. After the incessant rains we have had for the last eighteen months, it is possible that the level of the water in these wells may have risen, but the first drought will cause it again to fall, and every improvement which takes place in the land drainage of the exposed surfaces of the water-bearing strata must tend to increase the exhaustion of their lower basin.

Although the exhaustion of the chalk, and of the basement bed of the London clay, has been thus markedly ascertained, it is curious that the Kent Waterworks Company should lately have succeeded in bringing to the surface a very large quantity of water by means of some wells sunk in the valley of the Ravensbourne, just before it falls into the Thames, and in the chalk itself. The yield of these wells is sufficiently great to enable the company to dispense almost entirely with its supplies from the Ravensbourne, and the water is bright, clear, and singularly wholesome and pleasant. It seems to me that the explanation of this anomalous flow of water is to be accounted for by the interference with the flow of the subterranean currents in the lower beds of the chalk: firstly, by the great line of fault which has given rise to the valleys of the Lea and of the Ravensbourne on their respective sides of the Thames; and secondly, by the upheaval in an east and west direction which is known to exist between Windsor, Brentford, Deptford, Shooter's-hill, Grays, and the extreme north-westerly point of the *embouchure* of the Medway. In all probability, also, the same upheaval has thrown to the surface the spring which has lately been shown to exist on the north bank of the Thames, opposite to Gravesend; and I should be much disposed to believe that for many years to come large quantities of water would be obtainable from both the wells of the Kent Waterworks Company and from the newly-discovered spring, without producing any sensible depression of the water-line. At Woolwich, it is true, the Plumstead Company was obliged to sink, or to bore, to a maximum depth of 525 feet before it could obtain even a small supply; but the works were placed on the lower side, in the direction of the dip of the north and south fault of the Ravensbourne valley, and between the latter and the valley of Cray and Darent; so that the contributing area was forcedly a limited one, especially as the boring was not carried down to the more permeable and more highly-charged strata at the base of the chalk. I have heard of Artesian borings having lately been successfully made in the chalk at Bermondsey; and I have little doubt but that similar results would be obtained by sinking down to the chalk marl near the margins of any of the lines of fault already noticed: the effect of pumping liberally from such wells would however only be to exhaust the supply; and in time it would be found that the phenomena already observed in the upper chalk would be reproduced in the lower beds. It would be long, no doubt, before this effect would really take place; and in the meantime we may dwell with satisfaction on the discovery of the new sources of supply at Deptford and at Grays.

---

* Paper read before the Society of Arts.

The history of the wells in the Deptford valley is the more interesting, from the fact of the failure of the attempt to secure a large supply of water from a deep well at Highgate; and it seems to me also to point a moral, which might be very useful to all connected with well-sinking. The Highgate well was commenced with the belief that by passing through the London clay and its subordinate beds—the chalk, the upper green sand, and the gault—a supply would be obtained from the lower green sand, in the same manner as at the Artesian well of Grenelle. It was known that the lower green sand outcropped on the margin of the gault all round the northern, western, and southern sides of the London basin; and certainly there was no *à priori* reason for doubting the continuity of the stratum beneath London. But after passing the various strata, including the gault, in the precise order anticipated, and of a total thickness of 1113 ft. 6 in., the boring tools, instead of entering upon the lower green sand, as was then anticipated, passed into a series of beds of sands, sandstones, red clays, &c., which have been considered by geologists to belong to the new red sandstone series. From the results of some other borings recently made near London, I am disposed to believe that these beds are members of the Wealden series rather than of the new red sandstone, notwithstanding the apparent confirmation of the latter theory by the results of the borings at Calais, Ostend, and Harwich, to which I hope to be able to call your attention on a future occasion; but to whatever portion of the geological series they belong, the effect of their intrusion has been entirely to intercept the flow of the water of the lower green sand under London. Under such circumstances it was manifestly impossible that water should be obtained at the Highgate well from that formation; and as the chalk, the chalk marl, and the upper green sand yielded comparatively no water, the prosecution of the works was abandoned. It may be added that the Hampstead Company, at whose expense they had been carried on, was shortly afterwards compelled to part with its district to the New River Company.

Now the lesson which may be learnt from this story seems to me to be, that there is little chance of finding water in any deep well in formations like the chalk, if that well should be sunk in the intermediate zone between two great lines of fissures, such as have given rise to the outbursts of the springs in the valleys of the Colne and the Lea; and it is to be observed that the indications of these lines of disturbance are to be traced on the south side of the Thames, respectively in the valleys of the Wey and of the Ravensbourne. It would seem as though the subterranean waters accumulated near the edge of the fault, and were there forced to the surface: and it is worthy of notice that the springs which supply the four rivers above mentioned almost all rise on their western banks; that is to say, on the bank corresponding with the upper edge of the dip of the strata. In such case the water might even be forced up a free open passage between the disrupted faces, more easily than it would rise in a well sunk through the superincumbent strata: and a current once established in such a direction, a well sunk near the apex of the intermediate district would not receive a larger supply than would arise from the precise area itself had laid bare. The water flowing in the intercepted stratum for a width equal to the dimensions of the well would flow into the latter, but no more; and the only way of increasing the yield of such a well would be by driving a heading across the line of dip, at the level of the water-bearing zone. This at least is certain, viz., that at Highgate and at Woolwich the wells were sunk below the natural water-line of the valleys of the Lea and of the Ravensbourne, and no considerable volume of water was obtained in either of them.

Now to revert to the condition of the actual water supply of London, you must be aware that, subsequently to the passing of the Metropolis Water Act of 1852, all the companies have been obliged to remove their sources of supply from positions where the waters were likely to be effected by the tidal action, or by the emanations of large manufacturing districts. The West Middlesex, Grand Junction, and Southwark Companies take their water from the same spot on the banks of the Thames, above the village of Hampton, and above the second lock on the navigation; the Lambeth and Chelsea Companies take their water from Kingston, above the Teddington lock; the East London and New River Companies take their water from the Lea, the first from a lateral branch from the main stream given off above Clapton, and the latter from the river above Ware; whilst the North Kent Company takes its water principally from its wells, and partially from the Ravensbourne. In all cases the companies are bound to filter the water, and the arrangements for that purpose are of the most elaborate description, and are, moreover, very conscientiously carried into effect. All the storeage reservoirs are covered, and in fact every precaution has been taken to insure the purity and the good quality of the water supplied to the inhabitants of London. Whatever can be effected by skill and science for those purposes has been done; and yet, month after month, the Registrar-General has thought it to be his duty to make comparisons between the water supplies of London and some other towns, which appear to lead to the conclusion that the London water companies supply a fluid of a very objectionable quality, even if they do not point to the necessity of a radical change of the whole system here adopted.

Without carrying you back into the Registrar-General's weekly returns of the public health, I would refer to those published at the beginning of October, November, and December last, in which the following tables appear:—

1860.	October.		November.		December.	
Supply.	Total impurity per gallon.	Organic impurity per gallon.	Total impurity per gallon.	Organic impurity per gallon.	Total impurity per gallon.	Organic impurity per gallon.
Distilled water	0·00	0·00	0·00	0·00	0 00	0·00
Loch Katrine, Glasgow...	3·16	0·96	3·16	0·96	3·16	0·96
Manchester	4·32	0·64	4·32	0·64	4·32	0·64
Great Yarmouth... ...	20·96	3·04				
Well, Great Titchfield-st.	...	...	140·68	16·68		
Ditto, Bexley-street, Camberwell	...	...	...	...	214·00	12·80
Thames Companies.						
Chelsea	21·40	1·88	21·12	1·12	20·84	2·08
Lambeth	21·20	2·08	21·88	1·68	20·28	1·24
Southwark	20·40	1·12	19·64	1·08	21·60	1·80
West Middlesex... ...	20·16	1 24	20·68	1·68	20·04	1·84
Grand Junction	20·28	0·84	20·96	1·36	21·88	1·60
Other Companies.						
East London	23·40	2·04	22·44	1·48	21·48	1·40
New River	20·08	1·12	20 32	1·12	22·30	0·84
Kent	24·64	1·60	23·78	2·68	22·40	0·56

Now the value of official analyses of this description depends on the extreme care taken with them, and the precautions observed to secure correct results; yet we have this singular fact upon the face of the above table—viz., that the analyses of the supply from the Glasgow and from the Manchester waterworks for the three last winter months—during which heavy rains and snow fell, and the trees and shrubs upon the respective gathering grounds must have furnished a number of dead leaves able to affect the quantity of organic matter in the waters flowing from those grounds—the analyses have been identical. The comparison between the fixed quantity of organic matter assigned to the Glasgow and the Manchester water supplies on the one side, and the variable quantities asserted to be found in the London water supplies, goes for nothing under these circumstances. Again, in none of these cases has any public statement been made of the nature of the organic matter said to be contained in the waters, although it is universally admitted that the injurious effects of the organic matters in question depend upon the quantities of the nitrogenous elements they may contain in a state able to undergo decomposition. The nitrogen of the organic elements which have undergone decomposition is stated by Hofmann and Blyth to be innocuous, but in the tables above given it is included with the other "organic" matters; and it is by no means impossible that the actively dangerous elements may exist in the greatest proportions precisely in those waters which contain the smallest numerical quantities of the class here grouped under the same name. But be this as it may, it is worthy of especial remark, that on several occasions the London waters have presented quantities of organic matter which are actually less than those permanently assigned to the waters considered to be the "types of wholesome town supplies."

As to the inorganic impurities in a town supply, there is still so great a variety of opinion as to their influence, that it would be presumption in any one man, or even in any one body of professors, to pass a decided opinion on the subject. From the earliest periods to the present day it has been held by the most competent inquirers into this branch of pathology, such as Hippocrates, Chossat, Dupasquier, Levy, Dumas, &c., that waters containing a small quantity of the bi-carbonate of lime in solution are those which are the most advantageous for human consumption. It is precisely the bi-carbonate of lime which constitutes the bulk of the inorganic impurity of the water flowing from the various formations of the valley of the Thames; and it appears from the results of experiments on water obtained directly from the chalk, that there is a larger proportion of that ingredient present in them than there is in the waters originally derived from chalk springs, but which have flowed for some time in the open air. The wholesomeness of chalk water, when clear and free from mechanical impurities, is too well known to require more than a partial allusion; and it must therefore be a matter of surprise to those who reason upon these matters to find that the confidential advisers of the central administration should thus persistently dwell upon the amount of impurity supplied to London, when it is by no means proved that the so-called impurities are not positively advantageous under many conditions of a town supply. No details of the nature of the officially branded impurities of the London water are given; but from analogy, and from isolated experiments, it is fair to suppose that out of the 21 38 grains of impurity per gallon there are, in addition to the average quantity of organic impurity, or 1·395 per gallon, about 16 grains of the carbonate of lime, with variable proportions of the salts of potash, sodium, magnesia, and calcium. These inorganic substances may even be supposed to play some useful part in the strange chemistry of life; and it is notorious that the water which does not contain them is often exposed to chemical reactions of a dangerous nature. Thus, for instance, in the case of the Woolwich and Plumstead Waterworks Company, the very beautiful system invented by Dr. Clark for softening the chalk well water, was applied under the very able management of Mr. Homersham, and the impurity was reduced from 23 grains to 7 grains per gallon. But at the same time it is to be observed, that the water so softened acted very rapidly indeed upon the lead cisterns and services exposed to it; so much so, I have been informed, as to entail a very heavy loss on the waterworks company. Again, the water of that "type of a town supply," Manchester, is now stated to be able—nay more, to be exposed—to take up lead in sufficient quantities to be deleterious to health; and the story of the lead poisoning of the family of the late ex-king of the French, through the use of soft water which had been stored in a lead cistern, must be in the memory of all my readers. I am myself disposed to suspect that there is some degree of exaggeration in the opinion held by those who have written on the deleterious action of soft water on lead; but the point to which I am anxious to draw attention is this, that until the absolute importance of the actions of various classes of water are known, it is dangerous to cite any one of them as the type of a town water supply, and thus by implication to create a prejudice against other sources of supply. The fact is, that the human constitution is a far more delicate test of the value of water for this particular purpose than any chemical analysis can be; and as the health of our London population is by no means inferior to that of the population of Manchester, or even of Glasgow or Aberdeen, whilst its moral habits are no better than those of the towns cited as having a more comparatively pure and soft water supply, it seems to me that there is something at least injudicious in the tone of the monthly criticisms upon the quality of the water distributed by the London waterworks.

There is moreover a very serious consideration, which, to my mind at least, overrides the whole of this discussion upon the quality of the London water supply, viz., that if medical and chemical authorities should agree that the present source of supply ought to be abandoned, there is positively no other source to which we could resort. The notion of forming gathering-grounds and catchwater reservoirs on Bagshot-heath was too absurd for even the late General Board of Health to support after it had been exposed to adverse criticisms for a few weeks. The scheme for collecting the waters from the Hind Head district also fell to the ground on examination; and I myself, from personal inspection of the district, know that not only was the quantity of water said to be obtainable from it seriously exaggerated, but that the estimated expense of the works was as seriously below what it really would have been. Even if both these catchwater schemes for securing a soft water supply were executed at any cost, they could not furnish the quantity required for the enormous population of London. At the rate of the Liverpool and the Manchester waterworks, where the rain-fall is greatly in excess of that of London, it would require gathering-grounds in the proportion of about 25 acres per 100 individuals; or for the supply of the metropolis it would require not less than 1000 square miles, or about one-sixth of the total estimated water-shed of the Thames; and it is preposterous to suppose that under any conditions of springs fed from other sources the districts it has been proposed to resort to could yield anything approaching the volume which would be required. As it is, the abstraction of fresh water from the Thames is in dry seasons becoming an evil of serious magnitude to the navigation, even when the New River, the East London, and the Kent Waterworks Companies derive their supplies from other sources than the Thames. What would be the case if the whole of the 100,000,000 of gallons now supplied to be consumed every day in London were withdrawn from the basin of the Upper Thames? It must indeed be observed, that if there be any real value in the opinion as to the hygienic superiority of the pure soft water, the whole of the town supply must be of that description, unless the new source be resorted to simply as the basis of a scheme in opposition to the companies already in possession of the supply. Far be it from me to pre-judge the question as to the necessity of any such opposition. All I seek at present to show is, that so far as regards the quality of the water supplied to London, there is no immediate reason for a change, and that there are as many objections to be raised to the qualities of the model municipal supplies, as there are to the unjustly attacked waters distributed by the London water companies.

In the year 1856, a series of articles under the head of "Visits to the London waterworks," appeared in the *Journal of Gas Lighting and Water Supply;* and in the same year a report to Mr. Cowper, president of the General Board of Health, was published; in both of which an account was given of the works executed by the metropolitan waterworks in compliance with the Metropolis Water Act, 1852. At the date of the publication of those documents nearly all that had been contemplated for the alteration and improvement of the existing system of supply had been completed, and since then little else has been done beyond the extension of the distribution into the continually extending suburbs of our marvellous agglomeration of houses, and some trifling modifications of the machinery required to meet the wants of some outlying districts. Perhaps the most remarkable events which have taken place since 1856 in the history of the London water supply, have been the completion of the works on the New River at Hornsey; the sinking of the new wells at the Kent Waterworks; and the utter failure of the Woolwich and Plumstead Company, from a combination of circumstances into which it is not my province to enter. The results of the very costly, and very equivocally successful experiments at Orange-street and Duck Island, have in no wise affected the question of the metropolitan water supply; and the schemes for supplying the extreme east of London from Grays, or the extreme south-east from the Cray or the Darent, remain still in the state of projects; the Hampstead Company, as was before said, has been merged into the New River Company. At the present day, then, the companies which supply the metropolis are:—1. New River; 2. East London; 3. Southwark and Vauxhall; 4. Lambeth; 5. West Middlesex; 6. Chelsea; 7. Grand Junction; and, 8. Kent. The capital embarked in these undertakings is enormous. From the returns to the General Board of Health it seems that the total cost, up to 1856, had been not less than £7,102,823; and at the present day it cannot be much below 7½ millions. In 1856 the aggregate nominal steam-power employed was not less than 7254 horses, and the quantity of water pumped was 81,025,842 gallons per day, on the average of the year. Nor would it be unfair to suppose that, in consequence of the increase of population since the date of these returns, that the present rate of supply must be nearly 100,000,000 gallons per day, or at the rate of about 40 gallons per head of the inhabitants. A service of this character cannot be lightly disturbed, and it behoves our rulers to observe especial caution in the manner in which they allow their agents to create feelings of dissatisfaction with a class of public contractors who have risked so much, and laboured so earnestly to discharge the duty they have undertaken. Perhaps the best proof of the earnestness with which the London companies have entered upon their task is to be found in the fact that they have spent no less than 2½ millions sterling for the removal of their sources of supply, for the filtration of their water, and for the improvement of their distribution since the year 1852.

Before closing these remarks I cannot refrain from saying that the inhabitants of London have been very far from seconding either the intentions of the legislature in passing the act of 1852, or the water companies in their attempts to improve the quality of the supply. The legislature unquestionably intended (whether rightly or wrongly) to facilitate the introduction of the constant service, as it is called, into London; and the companies have executed all the works incumbent upon them for that purpose. For my own part, I believe that the provisions in the act of 1852 on this subject must always remain a dead letter; because the substitution of the machinery required for a distribution on the constant supply for one upon the present intermittent supply, would involve an outlay on the part of the public equivalent to between £5 and £10 per house. Moreover, the waste of water upon the constant supply in a town like London—if it attained anything like the proportions it has done at New York and Boston—would instantly compel the adoption of measures to limit the rate of supply. Practically, I believe that the distribution of water in London must continue to take place as it does at the present day; but so long as this is the case, so long does it behove the London public to exercise a rigid superintendence over the machinery of distribution which is under their own control. It is in vain to change the sources of supply for the purpose of avoiding organic impurity; it is useless to filter the water and store it in covered reservoirs, if, directly that water enters the houses it is intended to serve, it is poured into cisterns which are not cleaned out from year's end to year's end, or into butts teeming with every description of organic and inorganic impurities. In this matter, as in many others connected with social and hygienic science, the public requires to be taught that the remedy for the most pressing of their evils lies in their own hands; and if the householders of London would only clean out their cisterns once a month—at least once every three months—we should hear very little of the "total impurity per gallon" of the London water. As it is, people who are not accustomed to think on these matters are apt to forget the real proportions of the impurity said to be present in the water referred to, and the public requires to be reminded that 22 grains per gallon only mean 1 grain in about 3182 grains, and that 1·4 grain of organic impurity of all kinds, only mean 1 grain in 50,000. If these impurities be poisons, they may be suspected to be slow poisons, of the kind Fontenelle could, at the age of eighty, afford to jest about, as he had taken them every day of his life; and we Londoners have an unfortunate habit of "persevering in living" under their effects.

It may be worth while to add that the average cost of the London water supply does not exceed five per cent. on the rental, for a distribution so copious as to attain the rate of 40 gallons per head per day, or nearly seven times as much as it ought to be, for, in fact, no one really uses much more than 6 gallons per day. They only who take the water pay for it, and the trading companies who supply the public are obliged to suffer all risks, and to contribute largely to all public burdens in the shape of rates and taxes; for instance, the assessments of the water companies to the poor rates vary between 9 and 32½ per cent. of their total rentals; and, moreover, they are by the very necessities of their position compelled to adopt every improvement in mechanical or chemical science as it rises. A very long discussion might be raised upon this part of the political economy of the discharge of municipal services, but it may suffice here to say that the experience furnished by the management of the Manchester Gasworks, and of the Southampton Waterworks, shows that wherever municipal bodies take upon themselves the discharge of functions which must be paid for in some way or other, there is great danger—firstly, that there will be injustice in the assessment of the payment; and secondly, that in the mode of working there may be extravagance, even if not abuse. The modern system of paying for the deficiencies in municipal budgets, occasioned by the inadequate charges for gas and water rents, by means of general and district rates, is, after all, only a disguised method of making the community at large pay a portion of the burden the consumers alone should bear. The system adopted in London, where they only who receive a benefit pay for it, is certainly the fairest one, and in the end past experience has proved that it is the cheapest.

The conclusions I am induced to draw from a careful study of the question of the present condition of the London water supply are as follows:—

1st. I think that the quality of the water is on the whole extremely good, and that the companies take every precaution in their power to maintain its character.

2nd. I am convinced that it is utterly impossible to secure a supply which should attain the supposed ideal type, even if that were desirable, which I do not believe.

3rd. I think that the greatest present improvement in the quality of the London waters would be effected by rendering it impossible for the population on the banks of the Upper Thames and its affluents to use the river as their outfall sewer. With all the local impurities thus cast into the Thames, the quantity of organic matter its water contains does not however exceed in any notable quantity those contained in deep-seated chalk springs which cannot possibly receive sewage.

4th. It seems to me that any extension of our present supplies should be sought for rather on the east than on the west of London, and on the edges of some of the great lines of disturbance there existing.

5th. It seems to me also that it would be a mere waste of money to attempt to execute any system of catchwater supply.

6th, and lastly. I think that there is both great injustice and great want of a true spirit of philosophy in the insinuations which are now constantly urged by the Registrar-General on the subject of the impurity of the London water. Pure water does not exist in nature, for even rain-water contains appreciable quantities of ammonia: thus, Barral states that the rain-water of Paris contains about 3 in 100,000 of organic impurity; and the well of Grenelle yields a water containing about 15 in 100,000 of impurity of every kind: but even if pure water could be obtained, it would be necessary to ascertain the precise nature and effects of the extraneous matters in any other definite water supply, before applying to those matters the term *impurities*. The Registrar-General's monthly reports, moreover, not being drawn up with the assistance of the officers of the companies, can only be regarded as *ex parte* statements by one who evidently has a strong bias against the companies or their sources of supply.

◆

DISENGAGING CATCH FOR THE MINER'S SAFETY CAGE, &c.*

By Robert Aytoun.

All previous disengaging catches with which I am acquainted are subject to the serious defect of disengaging sometimes when it is not wanted, or of not disengaging when it is wanted; and the means taken to remedy the one defect only make the other more imminent.

The catch which I have invented (Figs. 1, 2, and 3) is entirely free from these faults. It may be described as a species of clasp-knife, which it resembles both in form and the duty it has to perform—namely, that of cutting through an iron bolt, so as to allow the cage being disengaged from the winding-rope, as aftermentioned. Its handle, ABC, Fig. 1, and blade, ADE, consist almost entirely of three steel plates closely touching each other. The handle is formed of the two outer plates, which are separated, as usual in knife handles, by a spring along the back, and which is marked off by dotted lines in the figures. The mid plate represents the blade of the knife, which is not kept shut by its spring as in ordinary knives, but is slightly open. The pin A, on which the blade turns, serves as the bolt of the shackle, by which it is attached to the winding-rope. The shackle end of the catch is no wider than is necessary for strength. But the lower ends, both of handle and blade, BC and DE, are made somewhat wider, to admit of slots being cut into them, to serve as hooks for suspending the cage. The slots are made thus: having shut the catch, by pushing the blade home into the handle, as in Fig. 2, a vertical slot FG is to be cut from the middle of the lower end, right through both handle and blade, of a size sufficient to admit the link by which the cage is to be attached to it. The length of the slot may be twice its width. The blade being now opened, as in Fig. 1, the slots of both handle and blade are to be extended from their upper ends in the direction of each other, that is to H and I respectively. The length of these extensions need not exceed their width.

---

* Read before the Royal Scottish Society of Arts.

The action of the slots is as follows:—the catch or knife is first shut, which brings the vertical slots both of the handle and of the blade together, so as to form only a single opening, as in Fig. 2. The link by which the cage is to be fastened to the catch is then pushed up to the top of the vertical slot. Next, the blade is allowed to open by the operation of its spring, by which means the vertical slots, both of the handle and the blade, are moved away from under the link, which now finds itself at the extremities of the side extensions of the slots, resting on their lower sides, as in Fig. 3. In this situation, the junction of the cage to the rope is perfect. But its security depends entirely upon the spring; for if it were to allow the blade to shut, the two vertical slots would be brought together, and allow the link to escape, and the cage to drop. To prevent the occurrence of this mishap, to which all previous disengaging catches are liable, a strong bolt of soft iron, whose head is shown at K, Fig. 3, is passed through both handle and blade, and strongly rivetted. This secures the catch beyond the possibility of accident, and gives as much security as any link or shackle could do. At the same time the bolt may be cut, and the blade shut so as to liberate the cage, by the application of sufficient power. For this purpose, a strong iron ring LM, Fig. 3, within which the winding-rope travels, is secured close below the pit-head pulley. Its diameter is just sufficient to admit of the catch passing through it when closed. In the case of over-winding, when the catch, impelled with the whole force of the steam-engine and the momentum of the fly-wheel, reaches the iron-ring, the blade is at once shut, and the bolt sheared cleanly through, and the cage released. This is shown in the model, in which a bolt of copper is cut through at each experiment. The bolt is not broken, in which case it might be feared that sometimes it would stand the shock and not liberate the cage; on the contrary, it is as cleanly cut as if done with shears provided for the purpose. The reason is obvious; the handle and blade of the catch are composed, as was stated before, of three plates of steel, fitted closely together, and drawn still closer by the rivetted bolt, which will not let them part till the cutting of the latter is completed.

Fig. 1.

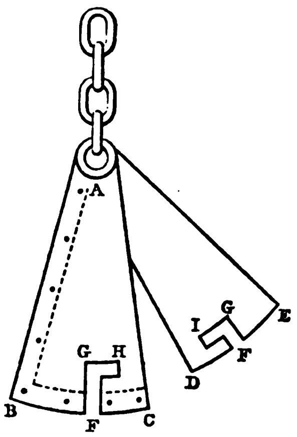


Fig. 2.

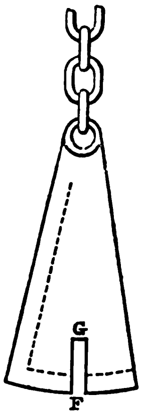
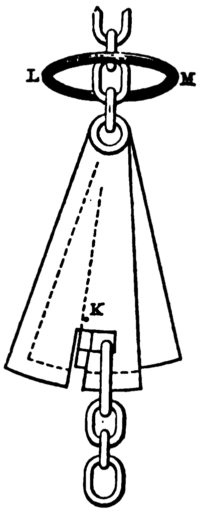


Fig. 3.



I shall have thus, I hope, established my two positions, that the catch cannot be disengaged by accident, and that it cannot fail being disengaged in a case of over-winding. I am happy to be able to add that I have not secured the disengaging catch by patent.

ON THE LARGE BLASTS AT HOLYHEAD.

By George Robertson.

(*Concluded from page* 40.)

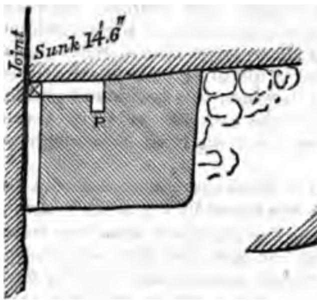
The objections to shafts are as follows:—

The miners not only work in a confined space, but to great disadvantage, as their work is below their feet.

The materials and men have all to be drawn to the top by a windlass; and the ventilation is bad, so much so, that after a small shot in the shaft was fired the men could not return to their work for some time, notwithstanding the windsails, water-tubs, and other contrivances that were used to remove the foul air. Any water also which may collect in a shaft, either from rain or wet joints, has to be removed, and will not drain out of itself. Shafts have some advantages, however, over headings. They weaken the whole column of rock from the top to the bottom, greatly helping the powder, and determining the line of fracture. They are also very quickly tamped, as the *débris* which comes out in sinking the shaft has merely to be thrown down again. This is of some advantage in wet situations, where the powder should be fired off as soon as possible. It is obvious that the same point in the rock may be reached as well from the face as from the top of the quarry, and often by a shorter route.

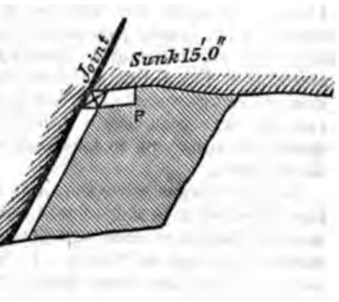
Headings, or galleries at right angles or nearly so to the face, are evidently in some points preferable to shafts sunk from the top. They are of a more convenient form to work in, the men having the rock in front of them, instead of below their feet; the chippings can be easily wheeled out; the ventilation is better; no rain falls into the mouth as in a shaft, and any water from joints drains itself out. A heading also forms a convenient place of safety for the miners while neighbouring shots are being fired. The usual size for a heading was 5 feet to 5 ft. 6 in. in height, by 3 ft. 6 in. Wherever it was possible headings were driven by the side of joints, and were generally placed so as to blow away a corner, as in Figs. 1, 2, 3, 4. When it was desirable to clear the bottom of the quarry well, the powder was placed several feet below the level of the rails.

Fig. 1.



Charge, 2340 lb.; produce, 5500 tons.

Fig. 2.



Charge, 2300 lb.; produce, 5500 tons.

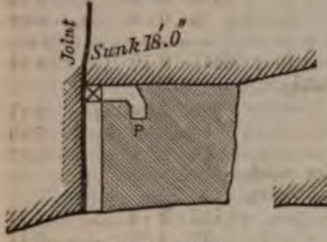
Headings are more nearly in the direction of the line of least resistance than shafts are, and the tamping is in consequence more liable to be blown out. They have therefore to be filled with greater care, and the direction of the gallery changed and sunk at parts, as shown in the diagrams.

Fig. 1 had a line of least resistance of 28 feet, with a height of face of 70 feet. The charge was 2340 lb., placed 3 feet below the rails, and the produce 5500 tons, or 2⅓ tons for each pound of powder. Fig. 2 is a very simple form of heading run along a joint not at right angles to the face. The line of least resistance was a foot more than in Fig. 1, but the charge of powder was rather less, viz. 2300 lb., as the face was but 60 feet high; and in Fig. 1 there was also a heap of loose stones at one side, which gave the powder more to do. The produce of Fig. 2 was 5500 tons, or nearly the same proportion to the pound of powder as in the last example. Fig. 3 was also driven along a joint, with a line of least resistance of 28 feet, and 85 feet height of face. The charge was 2500 lb. (1 ft. 6 in. below the rails), and the produce 6000 tons, or 2⅖ tons to the pound of powder. As in shafts, the powder was often divided into several charges. An instance of a double charge is given in Fig. 4, where the gallery follows the direction of one joint, and the principal charge of powder is placed at another joint. The sinkage in this heading was not, as usual, at the turn of the gallery, but in the centre of the straight portion: P_1 was 2400 lb., P_2 1800 lb.; the line of least resistance 33 feet, and the produce 2½ tons to the pound of powder, or 10,000 tons in all.

A double heading, with three sinkages, is shown in Fig. 5, where the face averaged 60 feet in height, and the lines of least resistance 29 feet. The produce was 12,000 tons, with a charge of 5100 lb.

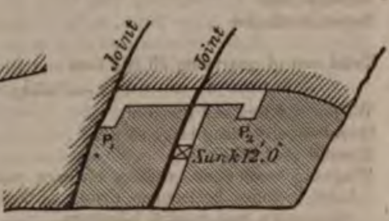
During the period referred to in this paper the largest mine fired was one of 5 tons of powder, producing about 40,000 tons of stone; but since then there have been others larger. One of the most successful ever fired at Holyhead was a heading with four charges, in which the joints of the rock were very favourably situated, as is seen in Fig. 6. The height of face was 146 feet, the length 140 feet, and the grip of heading 35 feet. The total charge was 13,000 lb. of powder, or 6½ tons (2000 pounds of powder going to the ton), $P_1 = 4500$, $P_2 = 4000$, $P_3 = 3000$, $P_4 = 1500$ lb. The produce was stated in the newspapers to be 70,000 tons of stone, or fully 5½ tons to the pound of powder. Unless the rock was very overhanging this quantity appears rather full. It may give a more popular notion of the enormous supply of stone brought down by these large blasts, when it is stated that Fig. 6 furnished an ample quantity to build the division of George-street (Edinburgh) in which this hall stands, with enough over probably for half of the opposite side; or there would be sufficient to macadamise the road from Edinburgh to Linlithgow.

Fig. 3.



Charge, 2500 lb.; produce, 6000 tons.

Fig. 4.

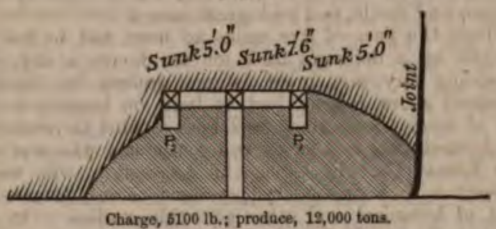


Charge, 4200 lb.; produce, 10,000 tons.

Larger charges were required for headings than for shafts, as the superincumbent rock was not weakened by the shaft column, and the height of face was generally great where headings were most advantageously used. It will be seen therefore that shafts and headings have each their peculiar merits and defects, and that a judicious mixture of both is the only proper way of working a quarry on the large scale. On the whole, headings preponderated, especially after the first two years' experience.

The usual method, when the face of the rock was not perpendicular, was to remove the upper half by a shaft, and the lower by a heading. When the face was nearly upright the heading alone was sufficient, as the top fell in when the root was blown out. A heading and a shaft fired together left a clean perpendicular face for the next mine. A good deal of forethought had to be exercised in placing the shafts so that they might be ready in rotation to keep up a steady supply of properly broken stone. They took many weeks to sink; headings, on the other hand, were driven in a much shorter time, and in this respect had the advantage.

Fig. 5.



Charge, 5100 lb.; produce, 12,000 tons.

The blasting powder was kept in strong vaulted magazines, and was landed from the hoys while the men were at dinner, and the locomotives out of the way. It was delivered in small barrels holding 50 pounds each, or half a hundred-weight (100 lb. being the hundred-weight of powder). One pound of powder = thirty cubic inches. The strength was tried in two ways; either by a gun, in which the recoil was measured on a graduated arc, or by a small mortar elevated at an angle of 45°. One ounce of good powder ought to throw a ball of 68 lb. weight to a distance of 180 feet. The different qualities of powder were sometimes mixed, to bring the strength near this effective standard. It was delivered at Holyhead for about £55 the ton.

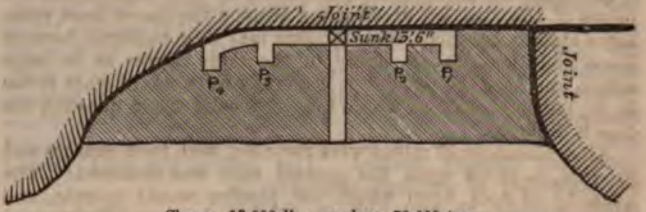
There is an idea amongst quarrymen that it is an advantage to mix powder with sawdust or quicklime; the former to divide the particles and cause them to ignite slowly, the latter to absorb any moisture. Both are erroneous notions; true economy is to use good powder, though for blasting it may be coarse grained.

In the shafts a space was sometimes left round the charge. Theoretically, I believe, this is of use in permitting the expanding gases to acquire momentum; but the space was so small in comparison with the quantity of gas evolved from such large charges, that it was practically of little use. The 50-lb. barrels were poured into a deal box of the calculated size for the charge. A box 3 ft. 4 in. cube would hold a ton. Bags were at first used, but were discontinued, and the powder lay loose in the box. There was little fear from damp, as a mine was never charged till the day it was tamped and fired. Inside the heap of powder was the bursting charge, which was a small bag of fine sporting powder inclosing a piece of wood, in two nicks of which the wires from the battery lay, with a piece of platinum wire between them. When the circuit was completed in the battery-house this grew red-hot, and fired the mine.

The battery wires in the shafts had to be protected from the tamping falling on them, and they were therefore laid in a groove cut in a batten placed up one angle of the shaft. At first a length of Bickford's fuse was also placed in this groove, in case of the wires missing fire. This occurred so seldom that the fuse was discontinued, it being cheaper to run the risk of now and then having to untamp a mine than to supply them all with fuses.

The wires from the battery-house were of copper covered with cotton-yarn or gutta-percha; these were unrolled from a drum to the required length. A considerable portion was recovered from the heap of stone after the blast was over. The batteries were placed sometimes in a heading, sometimes in a bombproof hut, according to circumstances. They consisted of earthenware cells, with plates in pairs of zinc and platinum, moistened with sand damped with sulphuric acid. The acid was thus economised, and kept from being spilt when the batteries were shifted over the rocks from one mine to another.

Fig. 6.



Charge, 13,000 lb.; produce, 70,000 tons.

Tamping a shaft gave little trouble; quarry *débris*, clay, and stones, were thrown down promiscuously. Headings required to be tamped with greater care. The charge was generally built in for some feet with a dry rubble wall, and the remainder of the gallery rammed with a red clay found in parts of the quarry.

The great shots were always fired after the usual small ones had gone off, on the hoisting of a red flag on the battery-house. If successful, there was little or no noise; the column of rock was seen to heave slowly forward, and crumble to pieces amidst a cloud of dust and smoke. The "rooters out" were apt to make a good deal of noise; and sometimes, in spite of every precaution and care in the calculations, the whole mass was blown across the quarry, tearing up rails and stopping the traffic for days. Very large lumps of rock were at times thrown a considerable distance, and these had to be reblasted and treated as separate rocks before they could be used. I have known a piece of 1000 tons thrown forward over the lines of rails.

At the bottom of nearly every blast there was a "core" of solid rock in the heart of the heap, which had to be removed by small shots to prepare a fresh face for the next mine. This core prevented any very accurate estimate of the quantity of stone yielded by a blast. This could only be told exactly by counting the number of waggons which were loaded at that heap. The waggons were all weighed as they went to the breakwater, and the contractor paid accordingly. The percentage of dirt varied, according to the part of the quarry and the height of the face of the rock, from one-sixth to one-twentieth. The first 6 feet below the surface was usually earth and rotten stone. All small stones and chippings were allowed to be deposited at a spot on the shore of the harbour, to form a beaching ground for vessels; but clay and earth were run to spoil. For a short time after a blast there was some danger in approaching the heap, owing to the foul air which hung about the stones.

In entering upon the calculations upon which the charges of powder were based, it must be premised that they were not to be relied on as mathematically correct, but were the nearest obtainable in practice. An unforeseen joint or crack, or some weak part of the rock arising either from texture or cleavage, would upset the best of calculations. But still, in the generality of cases the charges could be regulated with very great nicety.

Sir John Burgoyne's general rule for small shots is as follows:—one-half of the cube of the line of least resistance in feet = charge in ounces; or what is the same thing, the charge in pounds = $\frac{1}{32}$ of the cube in feet. This rule is sufficient for ordinary mining operations; but at Hoiyhead the desideratum was not only to move the mass, but to bring it down thoroughly broken up, and fit for loading the waggons at once. This the $\frac{1}{32}$ of the cube would not do, unless under the most favourable circumstances. After much experience, the general rules determined upon for Holyhead were as follows:—for ordinary shafts, from $\frac{1}{15}$ to $\frac{1}{20}$ the cube of the line of least resistance in feet = charge in pounds. For ordinary headings, $\frac{1}{12}$ of the same line cubed. In "rooters out" it was found necessary to increase these quantities to $\frac{1}{10}$ of the cube of the line of least resistance. But it will be easily seen, that with the same line of least resistance, the contour of the rock, the position of the mine, or the height of the quarry, might very considerably alter the work the powder has to do. With the same distance also from the face, the depth of the shaft, or distance from the top of the heading, might be 30 feet, or it might be 130.

It would be unreasonable, therefore, to base calculations for mines of the size we are treating of upon the line of least resistance alone. In small shots it alone may be considered, because these objections do not apply in the same degree as in large mines, and here the powder is generally in excess of what it has to do; but in operations where tons of powder are in question the case is different.

After a number of mines were recorded, with their charges and produce, a check upon the general rule was obtained. The quantity of rock upon which the powder would operate, and which the mine might be expected to produce, was determined beforehand. By a careful examination of the neighbouring joints this could be ascertained very closely. For a lower heading, where the powder does extra duty (being generally below the rails), 1 lb. of powder to every 2 tons of stone expected was allowed. When a top shaft was in question 1 lb. of powder ought to produce 3 tons of stone; the average over the quarries of both shafts and headings being 1 lb. of powder to 2½ tons of stone. The difference between the quantity of powder calculated in this way, and the quantity obtained with reference to the line of least resistance cubed, was the variable quantity, which was altered according to the position of the joints, &c Half the difference was taken in ordinary cases. For example, in a lower heading, let the line of least resistance = 30 feet; the height of rock = 60 feet; the average width of the column = 50 feet; then taking this last check rule we obtain

$$\frac{30+50+60}{\text{Say 12 (the number of cubic feet to the ton)}} =$$

7500 tons of expected stone.

$$\text{And } \frac{7500}{2} = 3750 \text{ lb. in the charge.}$$

Now, had we taken the line of least resistance as the only element in the calculation, applying the general rule for headings, we have—

$$\frac{30^3}{12} = 2250 \text{ lb. in the charge;}$$

a difference of 1500 lb. less than by the other method. In practice about one-half this difference, or 750 lb., would be added to the quantity obtained by the $\frac{1}{12}$ of the line of least resistance^3, to enable the powder to do the work required by the position of the heading. The charge would therefore be 3000 lb., instead of 3750 by the one method, or 2250 by the other.

The only remaining point now to be noticed is the cost of quarrying on the large scale. This I am enabled to give from a very accurate estimate which was made in November 1855, from the pay-sheets for a week, during which the quantity quarried was 23,095 tons, of which 1165 tons was *débris*, not deposited in the breakwater. This estimate includes quarrying, filling the waggons, and moving them clear of the face of the quarry.

				Pence per ton.
1.—*Quarrying.*				
Powder for headings and shafts	£269	8	10	2·80
Driving ditto	168	0	0	1·74
Superintendence	4	0	0	0·04
Total cost of quarrying 23,095 tons	£441	8	10	4·58
2.—*Filling.*				
Wages of fillers and gangers	202	15	4	2·11
Quarrymen blasting large stones	75	10	0	0·78
Powder used by ditto	11	8	1	0·12
Wages of carpenters, smiths, strikers, point-boys, toolboys, brakesmen, drivers of horses, platelayers, and general labourers	122	9	2	1·27
Foremen's wages	10	4	0	0·11
Cost of filling waggons	422	6	7	4·39
Total cost of stone quarried and filled, per ton	......			8·97

The miners' wages varied with the kind of work; in some parts of the quarry they got 25*s.* per foot run for driving a heading, in others only 14*s.*; out of which they had to pay about 2*s.* for the powder, fuses, &c. used in blasting. One man could drive fully 1¼ foot per week; the average over the quarries being 5 feet of heading for four men. In one case four men only drove 3 feet in a week, in another case as much as 10 feet; a low average therefore is 5 feet.

It is more than six years since I was at Holyhead, but I have no reason to suppose that the system of blasting has varied materially from what is recorded in this paper.

DESCRIPTION OF M. MARIETTE'S EXCAVATIONS AT GHIZEH AND SACCARA.*

By Professor Donaldson.

The lecturer commenced by observing that he thought some account of a two days' excursion from Cairo to the monuments of Ghizeh and Saccara might not be uninteresting to the members of the Institute. He visited Egypt very recently, for a more serious subject than merely making architectural notes—he went upon a practical one for the government; and therefore he could only employ a few days of leisure in the pleasure of visiting some of the ancient monuments of Egypt, of which he had read much, on which he had lectured much, and on which of course he had thought much. If they would allow him, therefore, he would give a brief description of a two days' journey which he had in going from Cairo to Ghizeh and Saccara. Many present, who had not been in the country to which he referred, might perhaps not be aware that the donkey was a very useful animal, and that the journeys of travellers in that country were generally made on the backs of donkeys, which were exceedingly intelligent and docile, and took great care of their burden. They went about the pace of five miles an hour, and he had been in the saddle on a donkey's back for ten hours a day, without experiencing any very great fatigue; indeed he should have experienced more fatigue had he been on horseback for that length of time. Sometimes travellers availed themselves of the aid of dromedaries; and he knew a gentleman, who was educated at the Roman Catholic College in Lancashire, who went into the desert with a dromedary, possessed of only a few dates, in pursuit of botanical and other scientific studies. On leaving Cairo, travellers took their donkeys, drivers, and dragoman, and off they started from Modern to Old Cairo, which was situated at the distance of about a league. He was in the country in the month of December, and it was then as fine as the early summer in England. The traveller went through Old Cairo, dismounted, got to the place for embarkation, went into the boat and crossed the Nile to Ghizeh, passing the Nilometer, indicating whether the Nile rose to a certain height at a particular time, which had great effect upon the prospects of the harvest of the country. Near the Nilometer were some monuments of very great interest. The traveller passed over the river and got to Ghizeh, from which was derived the name of the pyramids in the neighbourhood. Having crossed the Nile, the traveller got out of the boat or barge, again mounted his donkey, passed through various Arab villages, and through groves of date-trees. All the while, after getting to Old Cairo, the traveller saw the pyramids before him, and as he advanced they developed themselves gradually, over-topping all other objects. The traveller passed through fields and through groves of date-trees, and then arrived at the plateau of the rising bank of the rock on which rose the three great pyramids of Ghizeh. (The lecturer then referred to and explained a number of sketches he had made on the spot, representing the appearance of the pyramids from a variety of points of view.) The pyramids rose up above every other object near, and for twenty-five miles approaching from Alexandria towards Cairo they were always seen. The first moment he saw the pyramids it seemed to realise the whole history of a vast period, and to form an epoch in his life. They could easily imagine the emotions that arose in the bosom when first the traveller saw the pyramids. As the plateau of the pyramids was approached it was found that the villages were distributed to the right and left. As the traveller got close to the nearest village, or even before, the Arabs came to him offering to be his guides, and of course he had likewise his dragoman along with him. And he does not grudge the money he pays (sometimes too much) to the guides who soon haul him up to the top of the great pyramid. The great pyramid, as most of them might be aware, was cut out of the solid rock.—The Professor then proceeded with his account of the

---

* Read at the Royal Institute of British Architects, on the 18th ult.

Excavations at Ghizeh and Saccara.

M. Mariette, so well known for his researches among the antiquities of Egypt, has for some years conducted excavations for his Excellency Said Pasha, the Viceroy, and has had the control of all the antiquities of this country. No diggings are allowed without a permission granted through him. None of the fellahs can sell the smallest object, under pain of a severe punishment, extending, it is said by the Bedouin Arabs themselves, to death, if any article be offered for sale without having been first brought to him, to buy it if he choose for the Pasha's collection. He is now carrying on excavations at the Ghizeh platform, Saccara, and Thebes, where gangs of Arabs are at work, under the direction of their sheiks, with the slightest tool, and even with their hands, casting the sand, the dirt, and rubbish, into small baskets, carrying it out of the trench, and depositing it at a short distance, clear of the spot. This is a forced labour; each village in turn being obliged, as for other public works, to furnish and maintain its contingent without remuneration from the government. I observed that there were few grown-up people, the mass consisting of young boys and girls, who appeared very merry at their work, one or two of them singing a kind of couplet, constantly repeating the same words, the rest joining in chorus at the end.

M. Mariette is very stringent with respect to any strangers taking memoranda, sketches, or dimensions, and it was as it were only by stealth, and as though I were doing something else, to avoid observation, that I could put together a few notes of what I saw. In the illustrations, therefore, that accompany my remarks, these difficulties must be borne in mind, and except when I give positive dimensions, very precise accuracy must not be expected. It is to be regretted that M. Mariette does not supersede such imperfect data, by himself giving accurate descriptions of his most important discoveries. He has full knowledge of his subject, aptitude and felicity in knowing where to direct his researches, and great success has attended his labours, for the collection in the Museum at Boulak contains many objects of the highest value, particularly those found in the tombs. He ought himself to reap the full benefit and credit of his investigations. But his delays are unjust to himself and injurious to the study of Egyptian archæology; and he must not feel either displeased or surprised that a passing traveller like myself should seek to make known to his colleagues, however imperfectly, some of the discoveries brought to light from time to time, and in which all Europe feel interested.

I regret that I had not the advantage of seeing M. Mariette while I was at Cairo. I called twice upon him at Boulak. He was out both times; the first he had gone to Ghizeh with M. de Lesseps, the second time he had just started on the Nile to pay a visit of inspection to the operations carrying on at Thebes.

Tomb near the Great Sphinx.—M. Mariette has for some years been engaged in excavating a tomb upon the Ghizeh platform, within 100 yards of the Sphinx. This tomb, like that of Campbell, is sunk in the solid rock, out of which it has been excavated 30 or 40 feet deep. It assumes very much the form of a church, with a central aisle and an aisle on each side, separated by square pillars, with a transept at one end having a central line of pillars. There is a wide door at the end, leading into a kind of vestibule parallel with the transept, nearly as long, but only half as wide. In the vestibule there is a well of considerable depth, with water in it from the Nile. At each end of this vestibule are doorways, one leading into a gallery still filled with sand, the other into a wide passage running at right angles to it, the end also blocked up with sand. I should state that the whole of these parts have no roofing now, and are open to the sky. From the transept there are openings; that on the one side leads into three cells parallel with the aisles I have just described; they are about 10 feet high, and over them was a much larger chamber. The opening from the other end of the transept leads into a narrow passage, also running parallel with the nave and side aisles, rising in an inclined direction, and being apparently the passage of entrance. On one side of this passage, in the thickness of the rock between the passage and side aisle, is a chamber; on the other side of the passage an inclined passage leading to an upper story, probably over the entrance passage and the chamber last noticed. The inclined passage is lined half its height with large blocks of granite, and the other or upper half and the ceiling are lined with slabs of Egyptian alabaster 12 to 15 inches thick. A specimen of this alabaster I brought away with me, and it lies on the table.

The piers dividing the nave and aisles are monoliths, 4 ft. 9 in. by 3 ft. 4 in., and 14 feet high, upon which rested longitudinal beams or architraves about 3 feet high; most probably on those rested the transverse beams forming the roof or ceiling. The walls were lined with blocks of granite of different tints, some of deep red, others approaching to grey. I measured some of these as memoranda of the gigantic character of their construction, 15 feet long by 5 feet high; 11 feet long by 3 ft. 6 in. by 5 feet; and others 3 ft. 4 in. square on the face. The blocks in the angles had no joints there, but returned on the other face 2 or 3 inches, of course alternately breaking joint with the blocks above and below. This must necessarily have caused great waste of material and considerable additional labour. In the upper part, near the surface, I perceived some constructed walling formed of huge blocks of the rock itself, laid in regular courses. As I did not meet with M. Mariette at Cairo, I was unable to ascertain what had been found in this tomb, if any sarcophagus had been discovered, and the nature of any other particulars brought to light.

Before quitting the platform of the pyramids, I will venture to mention two or three other points with which I was struck. In front of the smallest of the three great pyramids there was originally a considerable court, with a dromos or avenue which led up to it. The walls are thick, and consist of blocks of the full depth of 6 feet, and in courses 6 feet high. I measured as the average length blocks 16 ft. 11 in., 16 ft. 9 in., 16 ft. 6 in., and 11 ft. 5 in. long.

When the bases of the pyramids were clear of the sand, debris, and blocks, which now encumber them, they must have had large platforms, the rock having been cut away to form the level. Consequently, at 100 or 150 feet behind the pyramids to the west the face of the rock gave a perpendicular height of 10 or 15 feet. In the body of the rock tombs were cut, having doorways opening upon the platform.

I found, on the lower part of the third pyramid, courses of red granite, several blocks remaining in their orginal position, and having the appearance of bossed blocks, 3 ft. 8 in. high, 3 ft. 6 in. deep from front to rear on the upper bed, and from 2 ft. 10 in. to 4 feet wide; they were wedge-shaped in plan, so as to form a key, and there was a curious angle-shaped channel on the face of some of the blocks lying about. The second pyramid was faced with a granite revetment in the same manner as the first.

(The lecturer exhibited specimens of alabaster, mortar, and basalt which he found in Egypt. He next proceeded to give some account of his journey to Saccara. Departing from Ghizeh, the traveller passed over the desert, with his donkey, donkey driver, and dragoman, passed by a lake, got to a kind of mound on which was a monument, advanced onwards and found other lakes, which were frequented by wild ducks, snipes, and other fowl, which sometimes afforded good sport and were found very convenient for supper. The traveller rose up in the desert ascent, and then he found a wild sequestered scene, having fragments of mummies and bones, and thus he passed on for miles to the village of Saccara. The next morning he was up before daylight, had the donkey got ready, and off they proceeded to examine the monuments which he was about to describe.)

Serapeion of Memphis.—The Bedouin village of Laxara, Saccara, is in a direct line about a mile or a mile and a half to the west from the site of Memphis. Up above the village, on the Lybian range of hills, are several pyramids, with an immense quantity of tombs, proving that this must have been the principal cemetery of ancient Memphis. The pyramids are crumbling away, still, however, retaining gigantic proportions; the numerous mounds by which they are surrounded indicate constructions beneath, or the excavations of Arabs or travellers in search of antiquities; and for miles the surface of the sands, which have accumulated to the height of tens of feet above the rocky level, are strewed with fragments of mummies, blanched bones, and other worthless fruits of the diggings of the curious; inspiring feelings of horror and disgust at the ruthless spoliation of these resting-places of the dead. Strabo mentions as at Memphis, of which this plateau must have been considered to have formed a suburb or part, "a Temple of Serapis, in a spot," he says, "so sandy that the winds fill it up;" and in it he saw sphinxes embedded, some half-way, others up to the head. It would, therefore, appear that in ancient times the same agencies existed, and it could have been by constant attention alone that the areas and dromo of the temples could have been kept free from the accumulation of sand. Mons. Mariette had seen a dozen sphinxes at Alexandria, and many at Cairo, brought from this part; and felt convinced that in this locality must exist the burial place of Apis, or Serapeion, alluded to by ancient authors. He was engaged four years in his researches through the sand, in many parts 80 feet deep, and discovered the dromo, or sacred avenue, leading from the Serapeion of the Grecian times to that of the old Egyptian dynasties. The ceremonies connected with the god Apis were very peculiar. He was a white bull, marked with black spots; great care was used in the selection of the individual animal, that he might fulfil all the conditions required by traditional usage. He was kept in his sanctuary with scrupulous devotion, and not allowed to have food of too nourishing a quality, lest he should become too fat. He was occasionally, but rarely, brought out and exhibited to the worshippers. He was not allowed to live beyond twenty-five years; arrived at that period he was slain, and his successor selected. They usually died at an earlier age; one is recorded whose death occurred when he was 17 years 6 months and 5 days old. It is said that £20,000 were expended for funeral rites, which were of the most sumptuous character.

The Serapeion which I visited had its connection with the temple of Apis, and is situate on the slope of the hill, about half a mile to the north of the great pyramid, and the descent to the present entrance is to the depth of some 30 feet or so below the general surface of the sand. We first passed along a narrow gallery about 45 paces long, then turned to the left some 25 paces, which led into the main gallery, 4 paces wide, and perhaps 15 or 18 feet high. The whole excavation is in the natural rock, which consists of a soft, friable grey stone, like indurated clay, with seams of striated or fibrous alabaster, from half an inch to an inch deep, and about 12 or 15 inches apart. The roofing of this gallery is semicircular in form, but the sides, up to the springing of the circle, are lined with courses of soft Thorah stone, in courses 14 inches high and 18 inches thick. Turning to the right down this wide gallery, sepulchral chambers present themselves on each side. Nothing can be more imposing. In the dark gloom of the excavations, lighted only by the glimmering flare of a wax candle or two, or by a few pieces of burning resinous wood, producing a doubtful gleam, these mortuary chapels—on a lower level than the gallery, and into which the eye intently gazed to catch sight of whatever might be within—presented a gigantic sarcophagus in the centre, 11 feet high, 12 ft. 9 in. long by 7 ft. 8 in. wide. Such at least was the size of the one I measured, although M. Mariette records others from 15 feet to 18 feet long, and 13 feet high. These enormous proportions have a very impressive effect. They are of porphyry, grey and rose granite, and basalt. The body of the one I drew was 7 ft. 8 in. high, hollowed out to receive the mummy and case, the sides and ends being left from 1 ft. 2 in. to 1 ft. 5 in. thick; the lid was 3 ft. 1 in. high, and splayed off at the top, with a level upper surface, 4 ft. 10½ in. wide. Each sarcophagus, without the lid, must have weighed 30 tons. Let us consider for a moment the labour employed to disengage such a mass from the quarry, to transport it several hundreds of miles from the upper country, to carry it from the Nile up to the level on the side of the hill, and then to convey it along the galleries, and to raise and to lower it into its permanent position. One of the sarcophagi in the rough still remains near the main entrance, as though in course of preparation for the mummy of the creature god. The floor of these lateral chambers was 3 ft. 9 in. lower than that of the main gallery, and the bottom of the sarcophagus was sunk some 3 ft. 6 in. below that. The chambers varied in size, and were lined with courses of Thorah stone up to the springing of the vaulted ceiling, like the main gallery. One sepulchral chamber I measured was 25 ft. 6 in. from front to rear, by 16 feet wide in the clear between the masonry; others measured, between the rock, 25 ft. 8 in. by 12 ft., thus varying in size. There are only three which have hieroglyphics; those of the one I particularly examined were not deeply chased, but rather thinly incised, almost in mere lines, as it were, on the outside surface, and very few characters. For myself, I did not find any hieroglyphics on the other sarcophagi that I examined. I saw twenty-five of these chambers, as shown on the plan, beyond which the galleries are encumbered by *débris*; but there are further continuations examined by M. Mariette, and I doubt not others are still concealed from view, containing probably other like stupendous sarcophagi.

M. Mariette discovered these subterranean deposits of the dead in 1851, and found forty chambers. One of these sepulchral chapels remained intact, just as it had been closed in the reign of Rameses II., some 3700 years since, and containing still the statuettes, vases, and trinkets usually deposited with the bodies, but of which the other chambers had been despoiled. Many votive tablets exist, some inscribed with the names of Darius and of Cambyses, the latter of whom profanely wounded one of the sacred heifers, which, however, an inscription proves to have survived some years after that event. I found a rudely-carved figure of a couchant lion in stone on one of the sarcophagi, 4 ft. 8 in. long, and 1 ft. 10 in. high.

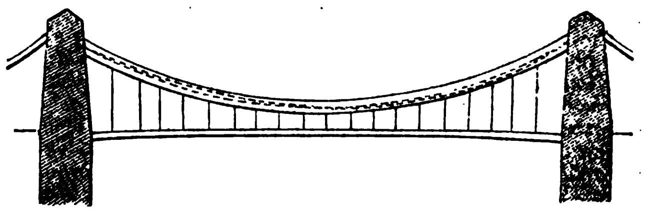
TENSION RIBS.

In our February number we promised to take an early opportunity of laying before our readers an investigation of "*tension ribs*," somewhat similar to the analysis already given of the action of the suspended girder. We now propose to redeem our pledge.

It is some years since Mr. E. A. Cowper first suggested this ingenious contrivance for combining the economy of the suspension principle with the firmness of the girder. For ordinary chains he proposed to substitute girders, constructed in the same curve in which the chains would dispose themselves when the loading was equable, and of such depth of section throughout as to contain within their limits every line of pressure possible under any distribution of the rolling load. An equally diffused load, therefore, would subject the girder chain, or rib, to simple tension; the line of resultant tension in this case being everywhere in (or close to)[*] the neutral axis: while a partial load would cause a tension the resultant path of which would sometimes lie very far from the neutral axis, although nowhere passing beyond either flange.

The first point to be looked at seems to be this: what are the strains thrown upon a girder by direct tension, acting on it at a certain distance from its neutral axis; and what kind and amount of reaction may we look for as the result?

FIG. 1.



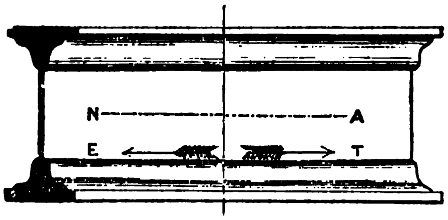
---

[*] Since settlement must take place, the actual line of tension must be a little below the neutral axis at the half-span.

In Fig. 2, let us suppose NA to be the neutral axis; the extensive force t (shown by the pair of opposite arrows ET), acting at the distance d from this axis. We may consider the neutral axis as passing through the centre of gravity of the section of the girder, so long as no part is subject to compression.

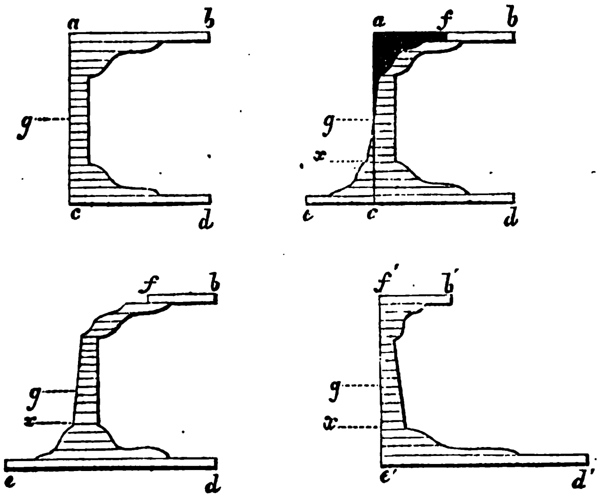
It is clear that the two flanges and the web of the girder must be in different degrees of tension. For if the tension were equable throughout, the resultant would be exactly in the neutral axis. To give a reaction answering to the resultant shown in Fig. 2, the extensive forces must increase in energy from the upper to the lower flange, so that while their total amount is equal to t, their centre of gravity may lie in the line ET.

FIG. 2.



To illustrate this by a diagram. If the tension t acted at the centre of gravity g, the figure *abcd* (Fig. 3), having a depth equal to the depth of the girder, a breadth everywhere proportionate to that of the cross section of the girder, and an area $= t$, would correctly represent the total tension on the girder; while the amount of reaction contributed by each portion from top to bottom would be accurately shown by cutting up the surface of *abcd* into corresponding slices by means of horizontal lines. But if the tension t, instead of acting at g, acted at some lower point x, the diagram of tension would be reduced above g by the area *afg*, and would be increased below g by the area *ceg*, these areas being of equal extent, and each tapering to a point at g. The tension, thus altered in distribution but not in total amount, will then be shown by the figure *bfed*, or the equivalent figure *b′f′e′d′*, equal to *bacd*, and having its centre of gravity at x. Thus the girder will be not merely stretched, but also bent, in consequence of the under flange stretching more than the upper. This bending shows a transverse strain.

FIG. 3.



The reaction which opposes the transverse or bending strain may be considered as made up of the successive portions of tension *in excess* or tension *in defect*, which compose the areas *ceg*, *afg*, acting at their different leverages about the centre g. The defective and excessive tensions thus make up a virtual moment of inertia like that which attends the compressions and extensions above and below the neutral axis of a girder in ordinary cases. The only difference being, that when every part is more or less in tension, the reckoning of this moment becomes all the more simple; because the neutral axis will fall in the centre of gravity, and the difference between the elastic forces of compression and extension has not to be allowed for.

The transverse strain caused by the tension t at the distance d (in feet) from the neutral axis, will always be equal to the product of $t \times$ the leverage d. To save space, we do not go into the proof of this, which the mathematical reader will easily supply.

A wrought-iron girder under a mixed strain of this kind will be transversely more stiff than it would be under a simple strain. The reason being that the weaker elastic force (that which resists compression) is not brought into play at all, the whole duty falling on the stronger elastic force of tension. At the same time it has to be remembered, that there is an excessive tension on one or other of the flanges, owing to the combined effect of the general stretching and the transverse strain.

We may now pass on to the more general question, as to what action takes place in the tension rib when the load is unequally distributed, and the line of pressure does not coincide with the neutral axis.

Since the rib is at once *chain* and *girder*, we must separate the functions which it simultaneously discharges, so as to get a clear understanding of each in detail. It is only in this way that we can gain any real insight into the complex action in which both are combined.

So far then as the chain-action of the rib is considered, we must altogether set aside the notion of rigidity, and reason as we should do of a perfectly flexible chain. So far as permanence of form results from rigidity, it is the secondary, or girder-action exclusively, that we have to consider.

As a chain, then, the form of the rib is such as demands an equal distribution of the load to insure equilibrium. The horizontal strain will be uniform throughout, and the resultant tension must be transmitted invariably along the neutral axis, no bending strain existing anywhere.

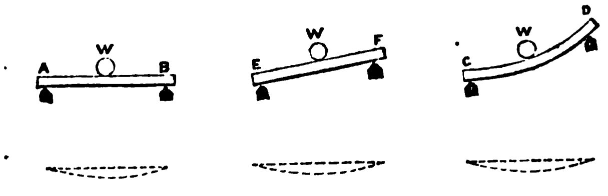
As a girder, the inflexibility of the rib effects the equal diffusion of a partial load, thus satisfying the conditions for the equilibrium of the chain. In doing this duty the rib undergoes transverse strains; these are to be measured, at the points where they occur, by the vertical distance between the neutral axis and the line of pressure, multiplied by the horizontal strain.

Thus analysed, the tension rib is seen to be simply a special form of suspension girder. As we have on a former occasion gone somewhat fully into the general theory of suspension girders, we need now only consider what is distinctive in the tension rib. In brief, therefore, there appear three points to look at. First, we have to examine the way in which the deflection of a girder is affected by making it curved instead of straight; and thus to determine the wave of the tension rib. We shall next consider the intensity of strain thrown at certain points on one of the flanges, owing to the rib having to do two duties in one. And lastly, the saving of material on the one system, compared with that on the other.

First, then, what will be the difference between the deflection of a girder of curved outline, and that of a straight girder, the horizontal span and other essential points being the same in the two cases?

Suppose AB, in Fig. 4, to be a girder with its ends supported on a level at a span $= s$, and let the load W cause in it a deflection$=d$. Suppose CD to be another girder of equal rigidity, and the same clear horizontal span, but of a curved outline, and therefore of course longer than AB. It seems at the outset reasonable to expect that W will cause somewhat more deflection in CD, on account of its greater length, than it does in AB. For if we take a straight girder EF, of the same section and the same horizontal span s, but fixed slanting, so that the span measures l on the slope, we shall find the vertical deflection under the load W increased from d to $d \times \frac{l}{s}$.* This shows that for a given

FIG. 4.



---

* The bending strains being the same in the two cases, EF will bend into an arc having a sagitta $= d \times \frac{l^2}{s^2}$: and the vertical deflection $=$ sagitta $\times \frac{s}{l} = d \times \frac{l}{s}$.

horizontal span the deflection will increase with the increase in length caused by raising one end of the girder. In other words, the vertical deflection of the girder EF is as the secant of its angle of inclination with the horizon. The same principle applies to the curved girder CD, but as the inclination here is not the same at any two points, but undergoes a gradual change, we are obliged to give the result in a form not quite so simple. It is as follows: let x and y be the co-ordinates of the curve of the girder, z the ordinate of the curve of deflection, k the coefficient of flexibility of the girder at the point (x, y), and m the moment of strain. Then, as is readily found by analysis,

$$\frac{d^2z}{dx^2}=\sqrt{1+\left(\frac{dy}{dx}\right)^2}\times km.$$

On the other hand, in the horizontal straight girder AB,

$$\frac{d^2z}{dx^2}=km.$$

From comparing these two equations we can very well see that *cæteris paribus* the curved girder will deflect in a different wave from that of the straight girder, and to a greater degree. But if the flexibility of the curved girder is diminished at each point in the ratio $1:\frac{1}{\sqrt{1+\left(\frac{dy}{dx}\right)^2}}$, the wave of vertical deflection will become exactly the same as that of the straight girder of uniform section.

Now in the curved girder which forms the tension rib in Fig. 1 we may take this to be pretty near the truth. For the area of the flanges should be gradually enlarged to meet the increased tension which comes upon the upper portions of the rib: and the tension would increase in the ratio $1:\sqrt{1+\left(\frac{dy}{dx}\right)^2}$. In a rib thus constructed, if K were the coefficient of flexibility at the lowest point, and m stood for the actual bending strain at the point (x, y), we should have $\frac{d^2z}{dx^2}=\mathrm{K}m$, from which it follows that z will be the same as in the common uniform girder of the flexibility denoted by K.

The deflection, and the compound wave, therefore, of the tension rib, including the correction for stretching and consequent settlement, will be altogether the same as those of the common suspended girder; provided the flanges of the rib are everywhere proportioned to the tension they have to sustain. Let us for instance take the case of a rolling road of 200 tons, covering half the span. The neutral axis being in the curve of equal loading (which will be a parabola), the line of pressure* will fall below this curve at the loaded quarter-span, just as much as it rises above it at the unloaded quarter-span; showing a downward or upward bending strain at either point, such as would be thrown on a common girder of half the span by a distributed load of 100 tons. The other strains at points on each side of either quarter-span (as found by measuring the vertical distances between the line of pressure and the neutral axis), will be seen to group themselves in pairs, and to be equal to the strains at the corresponding points of the common girder just referred to. Consequently, the depression of the loaded half-span and the rise of the other half-span will be equal, before the effect of stretching is allowed for; the undulation being in each case similar and equal to that of an unsupported girder of a span $=\frac{s}{2}$, carrying a distributed load of 100 tons, and having K for its coefficient of flexibility.

But inasmuch as the tension rib, being calculated to discharge the duty of both chain and girder, must be very much more massive than the common suspended girder, will not its rigidity be much greater; and may not the undulation be therefore expected to be far less in the former than in the latter kind of bridge?

Before answering this question, we have to take one or two things into account. In the first place, where strains are unequally distributed between the two flanges of a rib, it is of course the severest partial strain, and not the mean strain, by which the strength of the entire section is limited. Thus, if we think it prudent to keep the tension on rivetted plates at every point below 5 tons per square inch, and if the direct pull averages 3 tons per inch, the bending must nowhere be more than would throw the added strain of 2 tons on the lower flange. Now, when any part of the rolling load comes on the bridge, the rib must stretch, and take a proportionate settlement. It follows that the rib must be so shallow that the bending which accompanies this settlement, and the transverse strain produced by the partial load, combined, shall nowhere bring a strain of more than 2 tons on the lower flange. It is thus actually necessary to avoid making the rib too stiff, and therefore, although the flanges are greater, the depth of section must be less than in the suspended girder; so that it is by no means certain that the undulation would be much reduced by employing the rib, except so far as the greater stiffness of wrought-iron in tension (already referred to) affects the result.

In conclusion, while it is beyond a doubt that the tension rib is thoroughly adapted to answer the purpose of a rigid suspension bridge, and that as compared with a common girder bridge it would very greatly economise material, it is far from being equally clear that the arrangement is such as to gain the end desired at the least possible cost. In two respects there is a saving in the rib. First, in the increased stiffness of wrought-iron in tension; and secondly, in the saving of the *web* of the suspended girder. As to the latter point, however, some abatement should be made, because for a railway bridge there would always have to be some longitudinal platform girder, although it need be but a light one when suspended from the rib. But in some other respects the material does not seem so advantageously distributed in the tension rib, as in the combination of chains with a suspended girder. In the latter arrangement the transverse strength of the girder is fairly brought into play, without a preponderance of strain on either flange; while at the same time the tension on each link of the chain is uniformly diffused over its section. This equability of strain seems conducive to strength and economy in the suspended girder: whereas in the rib the strength of the whole is limited by the intensity of partial strains on one flange. As regards the cost per ton of a boiler-plate rib as compared with forged links and pins, any advantage the former might have in this respect would be likely to be fully balanced by the greater tensile strength, and consequent saving of material, in the latter: not to go into the question of wire cables, which have lately been so strongly recommended by some. Again, the weight of the entire rib is increased by its curved form, coupled with that increase of section from the half-span to the towers, which we have seen to be necessary. Now, although it is just the same with the suspension chain, the straight form of the suspended girder rids us so far of a quantity of material, not perhaps very great, but still worth the saving. In the last place, the suspended girder can be adjusted, or, if thought desirable, forced to a camber, by tightening the rods; which cannot be done in the case of the rib.

At the same time, although the balance of advantages seems to our judgment in favour of the suspended girder, the tension rib is well worthy of careful consideration. In any case where a large railway-bridge has to be planned upon the principle of suspension, a thorough practical examination of the details and cost on the one system and on the other, and a comparison of the results, would be pains well bestowed.

◆

REVIEWS.

On the Construction of Horse Railways for Branch Lines and for Street Traffic. By Charles Burn.—London: John Weale. 1860.

The traffic in the streets of the metropolis has increased lately to such an extent, that the attention of professional men has been directed towards this evil. There has been no want of suggestions for remedying it. Of the schemes which have been proposed with this view, and brought under the notice of the public, there are two which deserve consideration. The one proposes the construction of a railway from Westminster to London-bridge, or near to it. This railway is intended to run along the banks of the Thames, on an embankment, and to establish a direct intercourse between the City and the West-end, near the river,—thus relieving the main thoroughfares between these two points. The other plan which has been suggested for obviating the evil is a proper organisation of street tramways. It is the construction of the latter, and their general application, which the book of the above title considers.

---

* The line of pressure, namely, which meets the neutral axis at the points of suspension and also at the half-span. After settlement, the line of pressure takes a lower position.

It is supposed that if a more rapid and convenient transit of passengers were organised, a greater space would be afforded to the free passage of private and other vehicles. The introduction of street railways, then, would dispense with a great number of omnibuses, which now obstruct and often totally block up the streets of London, and would therefore remove one of the chief causes of the evil.

The object of the author however is not only to advocate the construction of horse-tramways for the streets of cities, but also for the high-roads and streets of the country. It is further to point out the advantages of such railway system for agricultural and mineral districts, as well as the construction of branch lines to small towns and villages, in order to form a direct communication of the latter with the existing railway lines of the country. With respect to the latter, he observes, that landowners who reside in districts from 10 to 20 miles distant from a railway station, are placed under great disadvantages compared with those in the immediate vicinity of a railway. The former have to pay at least ten shillings per ton for all goods forwarded to or from the railway, and find it accordingly difficult to compete with those who are placed in this respect under more favourable circumstances.

From the data brought forward by the author of this pamphlet it appears that the system of ordinary railways in England may be considered as completed. He shows that railways have been constructed too rapidly for our requirements. He maintains that locomotive railways do not answer for the convenient transit of goods and passengers between short distances and branches. The reason for this will be found in the established principle that, in order to work locomotives economically, their minimum speed should not be less than 25 miles per hour. But frequent stoppages, which would be indispensable for the accommodation of passengers, would prevent the attainment of such speed. Under these circumstances, then, the author proposes the adoption of tramways on ordinary roads. The existence of roads already provided with bridges, cuttings, drains, culverts, &c., facilitates their construction, and would considerably diminish the first outlay. As the motive power of traction, the author proposes to retain the use of horses, as in this case we can more conveniently adapt the required power to the weight to be transported.

Mr. Burn next refers to the application of tramways for the conveyance of passengers in the streets of cities. Street tramways have been introduced in the chief cities of the United States, and have proved to answer the intended purpose very successfully. Of the cost, earnings, and other statistics of the latter, a very detailed statement is given in the pamphlet. These particulars no doubt will be very welcome to those who are interested in the construction of street railways.

In the following chapter the author offers some valuable remarks on the construction and cost of this description of permanent way. He enters into a lengthy discussion respecting the width of gauge to be adopted. Many arguments have been advanced with the object of determining this important question. It is maintained by some that the gauge for these railways is not necessarily required to be the same as that of our ordinary railways. This determination would necessitate invariably an unloading of the goods when joining the main line of railway, and thus incur an extra item in the expenses of transport. The conclusions arrived at by the author, after a careful deliberation on the advantages and disadvantages of a narrower gauge or one of the same width as the existing railways, are, that for a country road a gauge of 3 ft. 6 in. would be sufficient, while for street railways a gauge of 4 ft. 8½ in. would be preferable.

Passing over the practical construction of the railway, we come to the cost of its execution. Under this head we find a series of estimates. They refer to the line proposed by the French engineer, from Clermont to Riom, in the department of Puy de Dôme. The weights and prices are reduced to the English standard, and may be of some practical value to the interested. The pamphlet is furnished with plates exhibiting a great variety of rails and sleepers, as advocated by the author and others.

On Heat, in its relations to Water and Steam: embracing new views of Vaporisation, Condensation, and Explosions. By CHAS WYE WILLIAMS, A.I.C.E.—London: Longman. 1860. [Third notice.]

The author continues to test the remainder of the theory of the heating and expansion of water, with which our last notice concluded. Although it has been said that water undergoes an expansion by being subjected to the influence of heat, Mr. Williams disproves this assertion. It is not upon hypotheses or inferences, but upon a close observation of facts and on carefully conducted experiments, that the conviction was based which induced him to dissent from the views of those who have gone before him. To the question, "Does water admit of expansion or not?" we give the answer in his own words:—

> "If water were a body to be dealt with in bulk, as a ball of iron or lead, and capable of receiving and conducting, from atom to atom, successive increments of heat, without any change in its status of liquidity, we might in such case correctly infer its expansion. But water, or indeed any liquid, has not that power or property of conduction among its constituent particles as metals or solids have, and consequently is incapable of expansion in the sense of such bodies. Besides, heat, that invisible and imponderable agent, knows nothing of the mass or contents of the vessel. It deals only with the individual atoms of which the mass is composed, whether liquid or solid, and with which it comes into contact. When also we consider how nature in its wonderful economy apportions the combining volumes, weights, or other properties of matter, there can be no disproportion between atoms of liquids or solids and units of heat. Their union is but part of the immutable law of nature, stamped on matter of all kinds. Each atom has not only its specific duty to perform, but the faculty of performing that duty; none will be tried and found wanting. The power of the wind is but the sum of the powers inherent in each individual atom. So of the waves; or a crowd of human beings. Pressures or power in the mass, is then but that of accumulated individuals or atoms. It is to these then, and their respective properties, that our inquiries should be directed.
>
> As water, or its constituent particles cannot undergo any change, physical or dynamical, without some sufficient cause, liquid particles at the temperature of 32° must continue at 32° until they have each received their equivalents of heat, by which they lose their status of liquidity. They are then, however, no longer liquid atoms,—they are absolute atoms of vapour. On what grounds then can we say that liquid atoms are heated and expanded, and still retain their liquid form and properties? Such an hypothesis would be contrary to the evidence of facts. To say that water can be a recipient of heat, or be expanded, while it retains the liquid state and is also a non-conductor of heat, would involve a physical solecism, irreconcilable with reason and common sense."

As a summary, then, on the heating and expanding of water, we quote the following conclusions arrived at by Mr. Williams:—

> "1. That water, or other liquids, being incapable of compression, are equally incapable of expansion. 2. That water, being a non-conductor of heat, must also be a non-recipient of it. 3. That as it cannot be heated or expanded and still retain its liquid form and properties, it cannot be thermometrically affected. 4. That its enlarged volume is attributable, not to any measure of expansion as a liquid, but to the presence of vapour in it in the state of an elastic fluid. 5. That this condition is in entire accordance with the recognised laws of all elastic fluids.
>
> The respective properties of liquid and vaporous atoms, as regards the changes they undergo by heat from the liquid to the vaporous state, may be thus described:—

LIQUID ATOMS.	VAPOUR ATOMS.
1—Gravity.	1—Gravity.
2—Latent heat.	2—Latent and sensible heat.
3—Mutual attraction.	3—Enlarged volume.
4—Mobility, *inter se*.	4—Increased temperature.
5—Non-conductibility.	5—Mutual repulsion.
6—Incompressibility.	6—Diffusion or divergence.
7—Inexpansibility.	7—Conductibility.
	8—Compressibility.
	6—Expansibility.
	10—Electricity."

In the next section of his book Mr. Williams pursues the changes arising from the communication of heat to water, until the latter arrives at the state of ebullition, and finally at the boiling point. We cannot but express our admiration of the truths elicited respecting the formation of vapour and its relation to the water. The constitution of the matter of water in reference to heat and temperature, the temperature of water and the temperature of vapours considered respectively, the unit of heat, and its meaning as regards the atoms of water and vapour,—these are the points discussed in this chapter. The great oversight to which the author draws attention here is, that water—in looking for the results of heat applied to it—has too frequently been considered as a mass, similarly as we would treat a solid body in connection with heat, and not as an aggregate of molecules or atoms. Mr. Williams says—

"In illustration of the theory of unity, or units of heat being sufficient for the generation of vapour, let us suppose a sheet of paper containing the smallest possible quantity of water, say in the state called damp. That quantity must still however be regarded as an attenuated sheet of liquid atoms. If the paper be then exposed to the air, at a temperature but a single degree in advance, these atoms will nevertheless be subject individually to the same process, and receive their respective equivalents of heat, and be converted into atoms of vapour, as if they had been portions of a large mass of water. Each, then, will also become as true and complete an atom of vapour as if it had been generated at the boiling point.

What, then, may be asked, is the quantity of heat which a body of water could receive and absorb, while still retaining its liquid form? Can it be more than that which its atoms had respectively received on being changed from the fixed state as ice to that of liquidity? If so, we are not warranted in assuming that water, or the unvaporised portion of the mass, can have any free or sensible heat; in a word, that water cannot be thermometically heated or influenced so long as it retains its status as a liquid. Why, then, look to it for that sensible heat which influenced the thermometer at 212°, or any other figure, seeing that the vapour, continuously formed and retained in the water, supplies an ample and legitimate source of influence, and that this view is at the same time consistent with physical appearances.

The oversight which so universally prevails consists in looking in the wrong direction for the results of the heat applied: first, in assuming it to be chemically combined with the body of the water, instead of with those only of its elementary atoms with which it comes into contact; and secondly, forgetting Dalton's well established law, that vapours, as elastic fluids, are but mechanically mixed with the liquid medium in which they may happen to be.

In neglect of these two all-important considerations, we look to the body of the water in its liquid form, as the chemical recipient of the heat, in the very face of the vapour which we see mechanically disconnecting itself from the water and thus carrying away that heat.

Water, then, in the liquid state, and at all temperatures, must be considered as a mechanical compound of liquid and vapour particles. So also the boiling point, and the temperature of 212°, must be considered without reference to the water, but rather as irrespective of its presence, as if it had merely represented a vacuum."

Having so far traced the process of imparting heat to water, and watched the results as to the formation of vapour and their repellent property, we next proceed to note the effects of a continued application of heat to water, that is, the state at which the atoms of vapour in water are in excess of saturation, as Mr. Williams very properly calls it, or the state of ebullition. This state will be reached when the repellent force of the vapour atoms *inter se* balances the converging pressure of the water surrounding them, for as soon as this self-repellent force of the vapours becomes greater than the force which retained them, they necessarily become disengaged from the surrounding medium, are aggregated in their progress upwards, and escape to the surface, where they explode,—hence the phenomena of ebullition. Respecting this state the author remarks:—

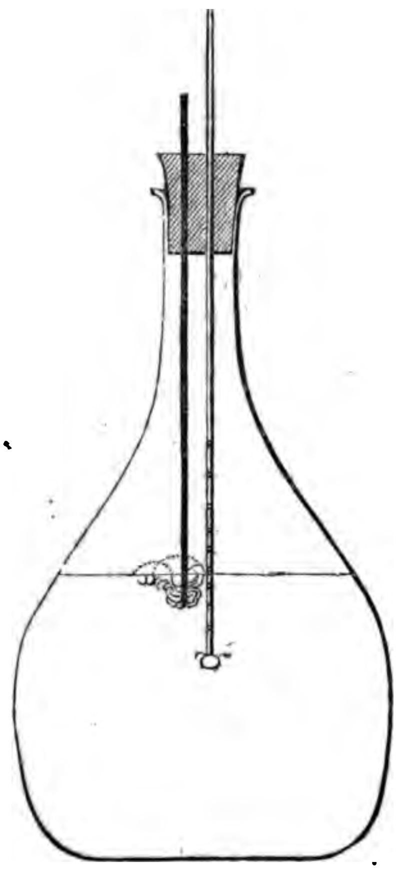
"This point of saturation, commonly called the boiling point, will then be determined solely by the quantity of vapour present in any given space; in water it takes place when that quantity indicates the temperature of 212° Fahr., in alcohol 176°, in sulphuric acid 630°, and in mercury 660°.

Let it now be assumed that 1000 atoms of vapour, in any given space, is the saturating quantity in water; until that quantity be present there will be no tendency towards these groupings, and consequently there will be no ebullition; nor, even though the required quantity should be present, unless there be some motes, points, or foreign matter present. To this alone is attributable the fact of the temperature of 220° and upwards being reached without ebullition, bubbling, or any disturbance or noise.

Some experiments may here be described as affording demonstrative evidence in support of these statements, viz.—Five pounds of well-distilled water at 60° were put into a perfectly clean bottle, with a thermometer inserted in a cork, as in Fig. 1. A small hole, ¼-inch wide, was left in the cork to allow the air and vapour to escape, and prevent any extra pressure. Through this hole also any foreign matter may be introduced. An Argand burner being placed under the bottle, and the temperature raised to 212° or above it, and without ebullition, the water may then be said to be saturated with vapour. In this case the water, according to Dalton's law, will be merely acting the part of a vacuum for the vapour or water gas.

To test the presence of the vapour and the fact of saturation, let the end of a fine rod or tip of a feather be introduced through the hole in the cork, as shown in Fig. 1, and pushed down just below the surface of the water. The presence of an excess of vapour will then be ascertained by its rushing into contact with the object introduced, around which groupings of vapour atoms will be formed, and collect in bubbles on the surface of even a large size. On pushing the rod or feather down into the water, and even to the bottom, these groupings will be increased in number and size, as long as there remain any vapour in excess of saturation. So soon however as that excess is discharged the temperature will have fallen to the saturating point, or 212°.'

Fig. 1.



Mr. Williams next adduces sufficient proof that the phenomenon of ebullition bears no reference to the generation of vapour, in fact, that this phenomenon is quite accidental, and assisted by foreign substances introduced into the water, where they act as nuclei for the grouping or aggregation of the vapour-atoms (probably by electrical influence); further, that vapour is contained in water long before ebullition becomes visible. He also explains the spontaneous generation of vapour by introduction of some heated body into the water. This phenomenon he illustrates by a series of beautiful experiments, convictive of the fact that ebullition is nothing more than the result of the aggregation of myriads of vapour previously formed.

This vapour must have been formed in the water. The existence of vapour in the water has been denied by other writers on the subject. The author of the present treatise however arrives at a different conclusion. He thinks it strange that the fact of a great quantity of vapour escaping from a body of so-called hot-water when poured out, should not have suggested its previous existence. And when we reflect that without such separate existence of the vapour in the water its volume could not have been augmented, that the repellent force or divergence of the atoms would have been arrested, and its elasticity destroyed, it must appear still more strange that this idea has not suggested itself. Are we therefore to believe that under the above circumstances these properties have resumed their existence, or that they have been suspended in each atom of vapour from the moment of its generation until the moment of its escape. Or that these vapours, instead of being formed at the bottom of the vessel near the source of heat, were generated at the surface when coming in immediate contact with the colder atmosphere? In the estimation of the author such results would be anomalies neither to be reconciled with fact nor with the evidence of our senses.

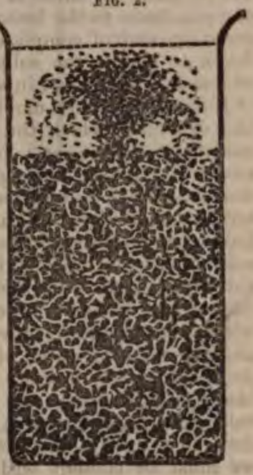
The following simple experiment will confirm our belief of the presence of vapour in water. Suppose a glass bottle to contain a certain quantity of water, say 4 lb. at 60° Fahr. Suppose, further, this bottle to be hermetically closed by a cork, through which a thermometer is inserted into the bottle, so that the temperature of its contents may be easily observed. By plunging this bottle into a bath of boiling water, and thus raising the temperature of the water it contains to 200°, the latter will expand and rise above its original level. On removing the bottle from the bath, and allowing it to cool by radiation, the level of the water will return to where it was at the commencement of the experiment, as soon as the thermometer indicates the initial temperature. Here, then, we have no loss of weight of the water, and all the heat communicated to it to raise its temperature to 200° was parted with again by radiation.

The quantity of vapour formed in water by raising it to a higher temperature will be observed in the following experiment. Take the same bottle as in the former experiment, with the same quantity of water in it. After having raised its temperature to 200°, remove the cork and thermometer, and pour it into an open vessel or dish. As soon as the temperature of the water has fallen to 60°, replace it into the bottle. The level of the water will in this instance be considerably below the original level, and on weighing the water it will be found to be reduced nearly 7 ounces in weight, or about 12 cubic inches in volume. There can, therefore, be no doubt that this deficiency was converted into vapour, and escaped into the atmosphere when at liberty to do so.

In proof of the existence of vapour in the water, as well as of its great ascending power, the following experiment is conclusive:—

> "It is true, as Dr. Robison observed, 'an experiment does not establish a general proposition, and never can do more than prove a particular fact.' The proving a fact, however, is a decided step in actual progress, and enables us to draw inferences and illustrations which, leading to other facts, brings us ultimately to absolute demonstration. Into a glass beaker put as much pounded coal as will fill it to a depth of 3 or 4 inches. Pour into it as much boiling water as will nearly fill it. Let the flame of a spirit lamp be then placed beneath, and touching the centre of the bottom. The result will be that the globules of vapour on being formed, will rise with such rapidity as to force their way through the mass of coal, and project it high in the water. This experiment, so unlike any that have been referred to by previous writers, shows how far we still are from having a correct view of the union of heat with the element of water. This experiment, though it may only prove a single fact, leads irresistibly to the following conclusions—namely, first, the absolute existence of vapour in the water; second, the formation of globules, or aggregates of that vapour; and third, the great ascensional power of those globules."

FIG. 2.



As the above theory deviates considerably from those promulgated by other writers, especially by the Comte de Pambour, the author thinks it no more than just to examine those theories. After having pointed out the erroneous conclusions derived by those writers, not so much from direct experiments as from mathematical deductions, Mr. Williams goes on to treat of the reconversion of vapour into water, or condensation, as it is commonly termed.

The supposed cause of the process of condensation is, that vapours, when coming in contact with a cold substance, part with their heat and recover their original state, water. An illustration of this process we find in the condensing steam-engine. It is in this case supposed that the steam, rushing by virtue of its elasticity into the condenser, and there meeting with a stream of cold water, is reconverted into the liquid state. But it is the object of the author to prove the fallacy of this supposition. He argues that, if the contact of water with vapour were sufficient to reconvert the latter to the liquid state, vapour could never be generated, nor any dynamical force be derived from its elastic or repellent properties. For it is evident, that the instant an atom of vapour were formed it would be instantaneously reconverted into the liquid state by the surrounding mass of water. From this argument, then, may be drawn the inference that water as well as other liquids cannot be considered as substances to which any heat can be imparted. Heat, therefore, cannot be received, as it were, by a liquid mass; as the particles composing it are susceptible to changes in their statical and electrical condition, and these changes are effected by union with more or less heat. The process of condensation as it takes place in the condensing engine, may therefore be explained in the following manner. The volumes of vapour when entering the condenser, and encountering there a jet of cold water, are compressed. Here the particles of vapour are held in bond by the surrounding medium of water, and prevented from fully displaying their elastic force. The vapour remains in this state until expelled to the atmosphere, or until it parts by contact with a cold body with its heat, and thus regains the liquid state.

Mr. Williams next considers, how the vacuum in the condensing engine is formed. Since condensation, in the true meaning of the term, cannot take place by a mere contact of the vapour with a jet of cold water, there must necessarily arise the question, how the vacuum is produced in the cylinder, and what is the cause of such being indicated by the barometer? Mr. Wye Williams says—

> "In the first place, the rush of the steam into the condenser, by virtue of its expansive property, would, as described by Watt, at once reduce the quantity in the cylinder by one-half, supposing they were of equal capacities. As however the usual proportions are for the condenser to be but half the size of the cylinder, the reduction of volume would only be one-fourth of that in the cylinder.
>
> Secondly, the cold water, by the mode of its injection, being spread and dashed against the inner surface of the metallic condenser, the latter necessarily becoming cold acts the part of a true surface condenser, in the same way as if the water had been made to act against its outside, as in the still. Thus an absolute conversion of the steam into water is effected, and an absolute *pro tanto* vacuum produced, in proportion to the extent of the available surface, and its reduced temperature. Had the inside surface been sufficiently extended, and cold enough, the entire of the steam would have been condensed, and a perfect vacuum formed. Practically, however, but a very moderate portion of the steam is so disposed of.
>
> Thirdly, the water ejected into the condenser becomes rapidly mixed with the incoming steam. So far, however, from the latter losing its heat or being condensed into the state of water, it is merely diffused, as already observed, on the true Daltonian theory, among it, in proportion to the respective quantities of each.
>
> It may then be broadly and unequivocally stated that there is no other mode by which steam can be condensed, that is—reconverted into water, than by the abstraction of its heat by metallic refrigeration, as is done in the still, or in Hall's system of metallic tubes. That, in a word, there is none other than Surface Condensation."

We have alluded before to the formation of vapour atoms from liquid atoms, or to the process of vaporisation, as explained by Mr. Williams in a former part of his book. It is now the liberation of these vapour atoms, or their escape from the water, to which we have to draw the attention of the reader. This latter phenomenon has been correctly denominated by Mr. Williams, "evaporation." It is remarkable that even writers of the greatest authority have so often confounded these two terms. "The more so," the author says, "as no two processes in nature can be more distinct." It has been supposed by Regnault, one of the first authorities on this subject, that the formation of vapour depended on the density and pressure of the air, or other medium in immediate contact with the water. This sufficiently confirms the belief of the erroneous inferences drawn by other philosophers. Regnault, in arriving at this conclusion, evidently confounded, or what is worse, did not distinguish between vaporisation and evaporation. Mr. Williams observes, "Had he said that the escape of the vapour from the water, after it had been formed, is influenced by the pressure of the air, he would have been correct."

Of the phenomena of evaporation the author gives a series of illustrations, based on Dalton's mode of illustrating the diffusion of vapours. The results of the experiments made by him, with the object of eliminating correct conclusions respecting these phenomena, may be enumerated as follows:—

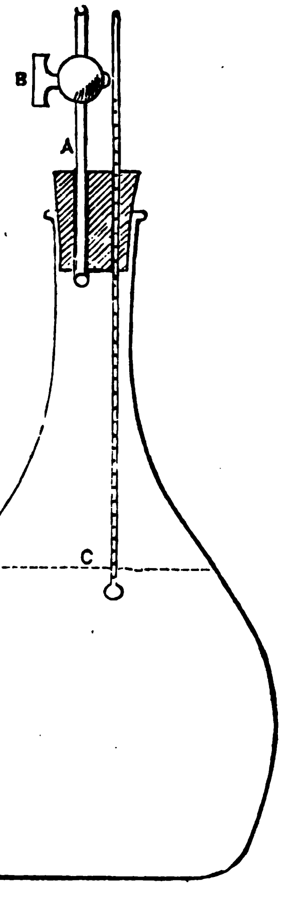
> "1. That the vapour which escaped unremittingly into the air, under the process of evaporation, must have previously existed in the water, its escape being proportioned to the area of the surface exposed to the lighter medium of the air.
>
> 2. That the reduced temperature was the concomitant of the reduced weight of vapour escaping from the water.
>
> 3. That the increasing time required for the escape of each quantity of vapour was clearly accounted for by the reduced quantity or number of atoms momentarily and successively exposed to the air in the upper stratum of the liquid under the operation of diffusion."

After having at some length remarked the phenomena of so-called spontaneous evaporation, and traced the mistakes and oversights hitherto committed in its interpretation, Mr. Williams offers some explanation of boiler explosions. With reference to the sudden increase of pressure, and risk of explosion, he writes:

> "We must bear in mind that, although under the influence of diffu-

sion, there will be throughout a homogeneous condition as to the quantity of steam present, that portion which is below the water line will be in a medium—the water—denser than that above it. The water and the space above it being thus distinct and separate media, may here be considered as separate chambers, though still in free connection. If, then the steam in that dense medium—the water—be by any means liberated and passed into the lighter medium above it (these densities being as 830 to 1), there would necessarily be a *pro tanto* increase in quantity, and, consequently in pressure in the latter. This difference would also be increased in proportion as the area above the water line would be less than that below it, as thus illustrated:—

Fig. 3.



Let Fig. 3 represent a five-pound bottle, with a cork fastened down by wire, through which the copper tube A, with the stop-cock B, was introduced, a thermometer being inserted through the cork as here shown. On heat being applied from beneath, and the temperature raised to 212°, or above it, the stop-cock was opened. The result was an immediate discharge of steam from the water medium to the space above it, accompanied by the appearance of violent ebullition, forcing much of the water before it, and a consequent discharge of both water and steam through the tube, with a rapid depression of the temperature to 212°. (If two thermometers were introduced, the bulb of the one being below the water line, and that of the other above it, both will be found simultaneously to fall to 212°.)

The experiment was then repeated, the quantity of water being so increased as to make the bottle nearly full. On the temperature being again raised to 218°, and the stop-cock as before opened, the result was a still more violent discharge of steam and water from below, a considerable portion of the water, together with the steam, being forced out, and rising to the ceiling, descended as from a shower bath."

From these and other investigations, it appears that boiler explosions cannot generally be attributed to the sudden formation of steam, but rather to the sudden liberation and consequent expansion of steam already formed, but previously existing in the water.

The above is but a brief summary of the valuable contents of Mr. Wye Williams' book. He has handed over to us, indeed, entirely a new theory. How far we are indebted to the author who elucidated it, and directed our observations into the right course, can only be fully appreciated by him who makes it his duty to peruse Mr. Williams' book, and to follow him in all the details of his inquiries,—a task which is sure to combine pleasure with useful information. We recommend this not only to those who are professionally interested in the question, but also to every one who makes it his endeavour truly to understand the harmony and the hidden workings of nature.

The Progressive Screw, as a Propeller in Navigation. By Julian John Révy, C.E.—London: John Weale. 1860.

There is little doubt that every engineer interested in the progress of steam navigation is well acquainted with the efficiency of the screw propeller, and the various improvements which it has undergone since its introduction. But among the many who know the results to be obtained from its application under ordinary circumstances, we believe there is but a limited number who have made themselves familiar with the principles of its operation. And again, out of this number there are in all probability only few who have ever philosophically considered the phenomena connected with the screw propeller, or who have traced with any certainty the complex laws of its action with relation to produced effect, so as to arrive at any definite conclusions of practical advantage. In making these observations, we intend by no means to question the abilities of our engineers to make such inquiries;—far from it. That such investigations have not been made by everyone, and every day, must be attributed more to the great success which has crowned the first experiments with the screw as a propeller, and the very extensive adoption it has met with, than to anything else. Moreover, the benefit we have so unexpectedly derived has made us forget to inquire, whether still greater advantages might not be realised by a radical study of the nature of the screw when moving in water and through it, instead of confining our investigations to endless and expensive experiments. That certainty on this point cannot but be of the greatest interest, will not be denied by those who have looked into the question deeper than the surface. By those it will also be perceived that, before we can penetrate to the bottom, a host of difficulties has to be overcome, no end of complications to be cleared up, before we can begin to handle the subject with the never-failing implements of reason. Let us see in what these difficulties consist.

If the screw were moving through a solid, we could, with all the exactness which the mathematical sciences now afford us, analyse its action, and foretell its effects. But the screw in navigation moves through a liquid; and it is here we encounter all the difficulties. The science of hydrodynamics has not as yet advanced so far as to furnish us with precise and reliable laws respecting the motion of the liquid particles amongst each other when impelled by other forces. Although we may know the force which is disposed of in acting against the water, we cannot *à priori* determine with exactness the amount of force which is necessary to move a certain quantity of water through another mass of water of indefinite extent, and for this reason do not know the number of the particles set in motion by the blades of the screw, nor the extent of such motion, and the velocity with which these particles move. From this it is evident, that until a distinct knowledge on these points is gained we must be content with arriving at results wanting mathematical exactness, and possessing only some degree of approximation to truth.

Few theories of the screw propeller which deserve acceptance by the practical engineer have been promulgated. Mr. Révy's book is therefore the more welcome, as it not only supplies this want, but also considers the practical application of the conclusions arrived at. He has endeavoured to clear away the above-mentioned difficulties, as much as the resources of science permitted, and has made it his aim to represent the manifold relations of action and effect of the screw propeller, in as concise and clear a form as possible, so as to render the book generally useful.

In the first section the author enters into a detailed explanation of the nature of the screw propeller, with reference to its most frequent application at the present time. To avoid repetitions, and also to enable the reader clearly to understand the reasoning pursued in these inquiries, Mr. Révy has devoted a special chapter to the treatment of "Elasticity," and the "Nature and quantity of forces." In the first division we find also valuable data respecting some experiments made with U.S. steamer San Jacinto, with remarks by the author respecting its performance. The second section of the pamphlet treats chiefly of the author's special subject, "The progressive screw." The first question in examining the phenomena of the ordinary propeller, is the resistance offered by the water to the surface of the screw; or, in other words, what is the velocity which must be imparted to it relatively to the water, in order that it may meet with sufficient resistance for the propulsion of the ship? This velocity is commonly denominated the slip of the screw. Any diminution of the latter, therefore, must have an increase in the useful effect for its consequence. According to the principles of the screw, the velocity with which the particles of water which come in contact with its surface are impelled, is in a direct ratio with the angular velocity of the screw, and its pitch. And as this relation is at every part of an ordinary propeller the same, those particles must be impelled at every part of the surface with the same velocity. If, therefore, such element of a screw were acting against water, the particles of it which were set in motion by the anterior parts of the screw's surface, would offer comparatively no resistance to those preceding it. But if a second screw were so connected with the former that the water passing from the surface of the first would be met by the second, it would be evident that this mass of water must exert a reaction on the second surface, which could only tend to the propulsion of the ship. From this then it follows, that the surface of the second screw—supposing it to be a prolongation of the latter—must have a continually increasing pitch; in other words, it must be progressive. This is the point discussed in the second section of Mr. Révy's book, as well as directions for the formation of the curve of its directrix.

Our space does not permit us to dwell any longer on this important subject. We consider that Mr. Révy has supplied a very valuable desideratum to the literature of engineering.

The Economy of Steam Power on Common Roads. By Charles Frederic T. Young, C.E.—London: Atchley and Co. pp. 417.

This work partakes more of the character of a *resumé* of the various modes of transport from its first development to the present time, than of a treatise on steam power on common roads. But, notwithstanding the historical features which this book presents, it is nevertheless a great advocate of the introduction of the latter.

Passing over the origin of roads at the period of the ancient Romans, and the early means of transport; the influence of facility of intercourse on civilisation in general; the construction and principles of road-making; the transport by canals and railways; and a comparison between the three with respect to their construction, maintenance, and advantages,—we come to the part of the book devoted to the history of steam locomotion on common roads. It appears that as far back as a hundred years, the application of steam to the moving of carriages as a substitute for horses has been fully appreciated, and suggested by Prof. Robinson, whose name is familiar in the biography of Watt. The author tells us, however, that the earliest account he has been able to find of the practical application of steam power to common roads is that of a steam carriage invented and caried out by a French military engineer of the name of Cugnot. Although several attempts were made by Symington, Watt, Trevithick, and others, to carry out this idea, the first steam carriage constructed in this country expressly for the conveyance of passengers on common roads, was invented by Julius Griffiths. It was constructed by the celebrated Joseph Bramah, but proved, after many experiments which were made with it at his works, unsuccessful, and was therefore finally abandoned.

It would be useless to recount here the numerous unsuccessful attempts which have been made in designing and constructing steam carriages for common roads. Let it suffice to say that Mr. Young's book gives an ample account of all those various schemes which have been brought forward from the early part of this century up to the present day, and which have formed, perhaps with few exceptions, the subject of a patent. From the fact of the number of abortive inventions which had for their object the realisation of effectual means for moving carriages on common roads by steam power, it may be concluded that there must have been something which was to a great extent the common cause of failure of all those schemes. The author thinks that, by the majority of those who were engaged in obtaining the desired end, very little consideration seems to have been given to the injury sustained by the road from a heavy weight moving over it, and from the loss of power arising from the system on which nearly all of those based their improvement—namely, on the concentration of weight. That this should be so, is perhaps not so unaccountable as one at first might be led to believe. The theory of action of the ordinary carriage, no doubt, was in all those instances too prominent to be lost sight of. Besides this, it is very probable —so the author urges—that they thought their system looked better, was simpler, that under favourable circumstances it could be made to work; and were influenced by many other reasons. Another great cause of the many failures of those steam carriages which were designed for traction purposes, is the little amount of adhesion which can be given to the wheels when drawing a heavy load on a common road. Various suggestions have been made to obviate this failure. For instance, a wheel with spikes has been introduced, or with projections or ribs on its periphery, so as to take hold firmly of the ground it moves over, and many similar contrivances. It became, however, soon evident that the removal of one failure only gave rise to another. The injury done to the roads by such contrivances was too serious to admit of their success. The idea therefore of overcoming the obstacles in this manner had to be relinquished.

In order to illustrate the effect of concentrated weight on the common road, the author has devoted to this subject a lengthy chapter. After having more especially pointed out the failures attending such system, he proceeds to describe the mode of obviating the mischief by distributing the weight on the wheels over a larger surface. Several patents have been taken out with this object in view, of which that of Mr. James Boydell is perhaps the most efficient. The chief features of his improvement (on the principle of distributing the weight over a large surface) is to apply and lay down by the mechanism of the carriage a series of detached and movable rails, on which the wheels roll as on a permanent way.

After giving a lengthy account of the efficiency and cost of working this engine, Mr. Young proceeds with a history of the progress of steam on common roads in the United States, and concludes his book by discussing the practicability of conveying passengers by this means. That it is not impracticable, he asserts; and that passengers can be conveyed by a steam carriage, at the rate of twelve to fourteen miles per hour, has been fully proved by Hancock, Gurney, and others. The reason, however, which has been advanced why such conveyances have not met with a more general introduction is the supposed injury inflicted by the wheels of the carriage on the road. But the opinions of Sir John Macneil, Mr. James Macadam, and many other authorities, is to the contrary. One of the main causes lies probably in the prohibitory and absurd tolls with which the greater part of our high roads is encumbered. It is said that fifty of such bills for raising road tolls have been brought into parliament, and passed at one time. Mr. Young has annexed to his book a return of private bills which have passed the House of Commons, and wherein any toll has been imposed on carriages propelled by steam or other mechanical contrivances.

We recommend the book to all interested in its special subject, containing as it does a large amount of information laboriously collected, and the publication of which at this moment is particularly opportune.

DOCK IMPROVEMENTS AT GRANGEMOUTH.*

By James Milne.

(*With an Engraving.*)

The dock works of the port of Grangemouth consist of an entrance wet-dock, having an area of 4½ acres; a junction basin beyond, area 3½ acres; a timber basin further beyond, area 12¾ acres; and a bonded timber basin, of 4¾ acres: the two latter being connected with the Forth and Clyde Canal.

The entrance dock is entered by the Carron river from the Firth of Forth, through an entrance lock 55 feet in width, having three pairs of lock gates, with a length of 250 feet between the entrance gates, and a depth of water on the gate sills of 24 feet at spring tides. The communication between the entrance dock and the junction basin beyond is by the building of the junction drawbridge, which has a width of 30 feet, and had a depth of 15 feet at high-water of spring tides. This building was completed along with the building of the entrance dock in 1842.

The means of communication from the junction basin to the timber basin, and thence to the Forth and Clyde Canal, is from the westward end of the junction basin, by the junction lock, which is 91 feet in length from point to point of gates, and 21 feet in width, with a depth of 13 ft. 2 in. at high-water of spring-tides, and a lift of 4 ft. 6 in. from high-water of spring-tides to the surface level of the timber basin and the canal reach. This junction lock was built in 1842, and the pig iron wharf on the south side of the junction basin was built in 1847. These works have generally been found suitable for the trade, except that the communication between the entrance dock and the junction basin has frequently been found to be too shallow for passing loaded vessels, which incurred either the removing of such vessels to the entrance dock for completing their cargoes, or the running of

---

* Read at the Institution of Engineers in Scotland.

DETAILS OF GRANGEMOUTH IMPROVEMENTS.

Fig. 1.

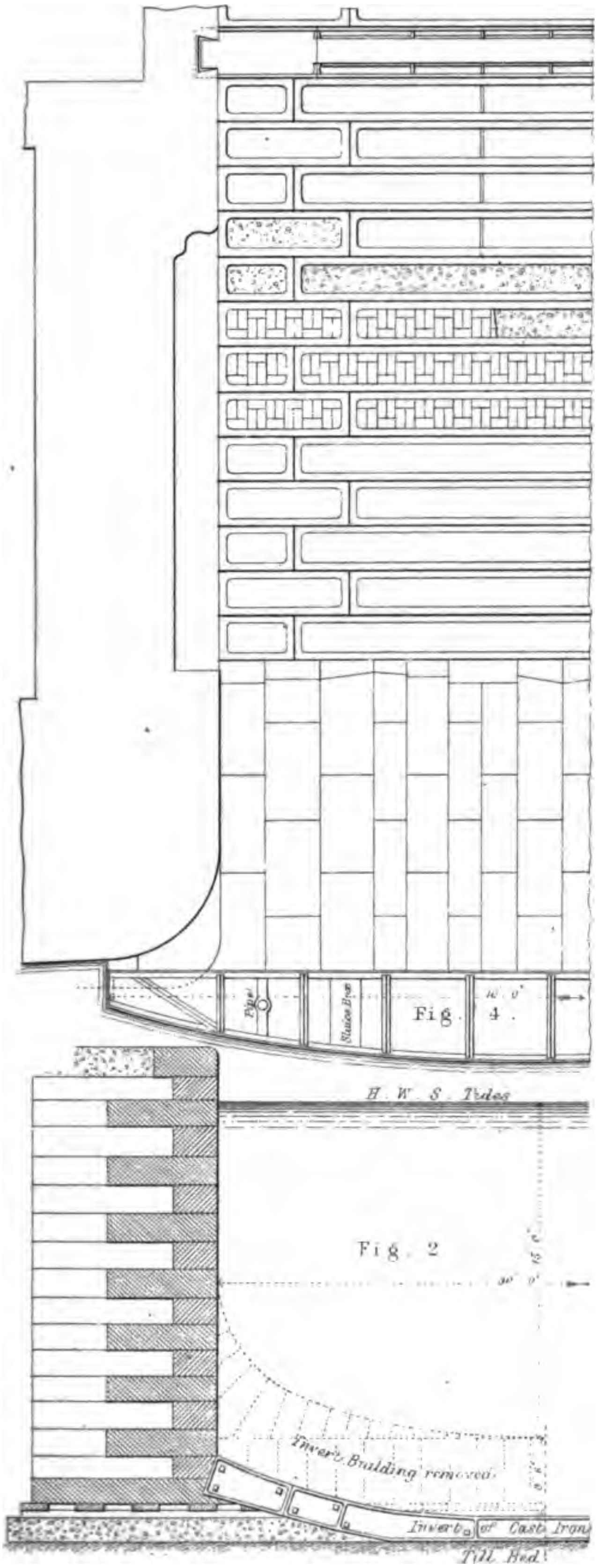


Fig. 3.

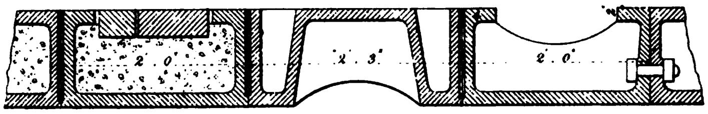


Fig. 6.
Cross Section at centre

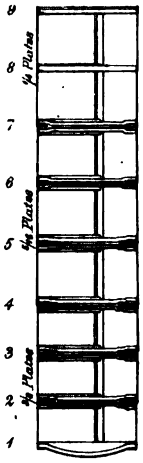
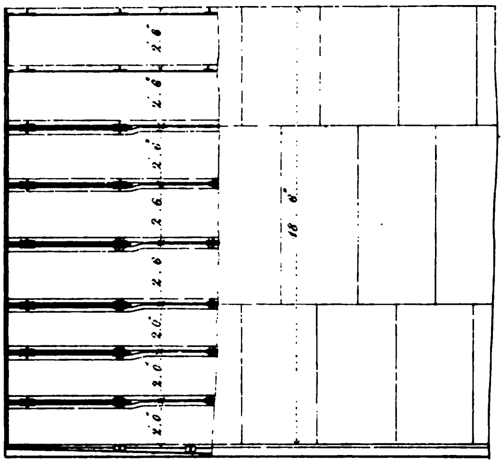


Fig. 5.
Sectional Elevation



At a a a a
Two ¼ Plates for 2 & 3
One ⅜ Plate for 4.5.6 & 7
and ¼ Plate for 8 & 9

Fig. 7. *Plan of Girders 2. 3. 4 & 5.*

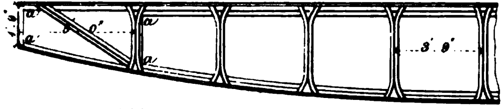


Fig. 8. *Plan of Girder 1*

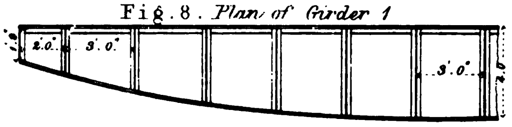
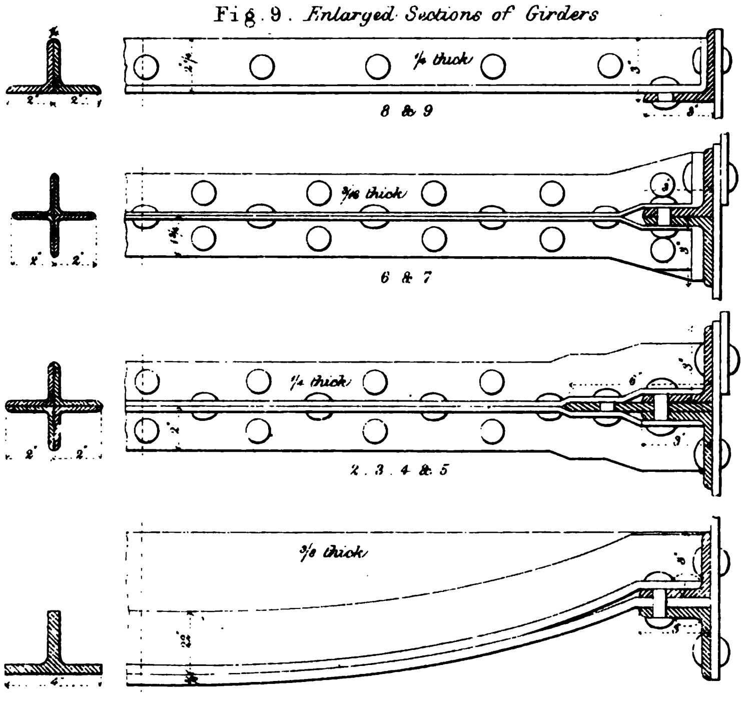


Fig. 9. *Enlarged Sections of Girders*



Scale for Figs. 1. 2. 4. 5. 6. 7 & 8.

Ins 12 0 1 2 3 4 5 10 15 20 25 Ft

Scale for Fig. 3.

Ins 12 6 0 1 2 3 4 5 Ft

Scale for Fig. 9.

Ins 12 9 6 3 0 1 2 Feet

J.R. Jobbins

water from the timber basin and the Forth and Clyde Canal supply to increase the depth of water in the dock and basin; whilst the dimensions of the junction lock, between the junction basin and the timber basin, have been found to be too limited for passing any considerable proportion of the vessels too large to navigate the Forth and Clyde Canal up to the said timber basin, having an area of 12¾ acres, and which might be considerably extended. Such was the general outline of the dock accommodation at the port for vessels of too large dimensions for passing along the canal navigation, when an increasing trade rendered it necessary to consider by what means, or in what way, the requisite increase of accommodation could be most suitably, easily, and cheaply supplied.

On testing the nature of the ground by bores put down, it was found to be soft alluvial deposit to the depth of 22 feet at the junction drawbridge, with a gradual rise towards the junction lock, where the depth of soft deposit measured 20 ft. 11 in. under the level of the surface of the coping at the junction bridge, which answers to 2 ft. 6 in. above high-water of spring tides, and is assumed as the datum line for the depths herein referred to. Lying at between these depths, a stratum or bed of boulders in hard till was traced by the bores put down, throughout the line of the new wharf wall and the cast-iron tunnel pipe; and by borings through the masonry at the junction bridge and lock, it was found that the stratum was intact under the walls, and that the walls were founded on two thicknesses of cross planking, each 6 inches thick. It may be stated that this stratum has been found unbroken throughout the scope of the new works, some portions of it being found to be softer than other portions, whilst it varies in thickness from 8 to 14 inches. The boulders were generally found closely bedded together in the till, and varying in size from that of small gravel to 8 or 9 inches through. This stratum lies on a bed of mixed fine clay and sand, from 2 to 3 feet in thickness, with soft mud under the bed of clay and sand.

After having proved the nature of the ground, and the depth to the only hard stratum within the limits of the depth for foundations, the general scheme resolved upon was to deepen the communication between the junction basin and the entrance dock to as close on the till bed as found practicable; to complete the junction basin to the width of 238 feet, giving an area of 3¼ acres in the basin; to dredge out the basin to the depth of the entrance; to deepen, widen, and lengthen the junction lock, so as to pass about three-fourths of the number of the sailing vessels arriving at the dock, from the junction basin to the timber basin; and to lay in a cast-iron tunnel pipe from the line of the new wharf wall to the old harbour, for the purpose of running water off the basin, and of scouring the mud from the old harbour.

The works were commenced by laying in the cast-iron tunnel pipe along the surface of the till-bed, from the old harbour to the line of the new wall. The pipes are spigot-and-faucet pipes, 26½ inches inside diameter, with a draw-sluice at the face of the new wall, and a hinged self-acting valve-sluice on the discharge end at the old harbour. After the pipe was laid in, a contract was made in July 1858 for the building of the wharf wall, and excavating the bed of the basin. The height of the wall from the till-bed to the surface of the cope is from 20 ft. 9 in. to 21 ft. 9 in. The wall is built of freestone, with ashlar in front, and rubble backing. The front line of the wall is curved to a radius of 3000 feet; the profile of the wall front to 8¼ feet under the surface of the cope being built with a batter of 1¼ inch to the foot; and from the 8¼ feet under the cope to the founds, to a concave of 40 feet radius: which gives a breadth of wall on the upper found course of 9 ft. 6 in., and a breadth of 11 feet for the lower found course. The lower found course is laid with Arden-lime mortar, on a bed of concrete averaging about 12 inches in thickness, and beaten over the till bed. The second course of found stones is bonded on the lower course, and the first course of ashlar and rubble is built with alternate headers from the front and the back of the wall,—all with the view of so bonding the foundation and base of the wall, and extending it over so much in area of the surface of the till bed, as to guard against subsidence. The excavations at the back of the wall are partly filled up with light pottery ashes, for the purpose of lessening the weight at the wall, and to guard against the strain of the filling-in of the mud behind. Cast-iron drain pipes, with brass faces on the pipes, and leather valve faces, are passed through the wall for running off water from behind the wall.

On the ends of the wharf wall being built as close to the waterway of the former basin as the safety of the bank would permit, the water was run off by the tunnel pipe. At the eastward end the new wall was joined to the wall of the junction bridge, and at the westward end the new wall was joined to the south wall of the basin, and a portion of the junction lock was taken down, and 40 feet in length at the lower entrance to the lock built in to the width of 25½ feet, whilst the bottom invert was lowered to 3 feet under the bottom of the present lock, this being a preparatory step to enlarging the lock. Such portion of the entrance to the lock was thus completed as would carry the turnpike road over the lock entrance, and give the means of damming off the water in the junction basin, so that the basin and the entrance lock might be available for the shipping whilst the lock was being enlarged.

Whilst the new entrance to the lock was being built, and the walls of the basin completed, the communication between the dock and basin was also being deepened by the removal of the original invert building, and replacing it by an invert of cast-iron girders, as shown in Figs. 1, 2, and 3, Plate XI. As a precaution against the yielding of the entrance walls, shoring logs were fitted in and firmly wedged between the walls. The cutting out of the ashlar bottoming and invert was begun at the end next to the junction basin. The ashlar, concrete, &c., were cleared out to the till-bed, and the first two girders bolted together, carefully placed into the line and level of the entrance, and ran in with Roman cement throughout the bedding of their lower sides, and the ends of the girders were caulked up with iron cement, so as to abut them firmly to the walls. All the subsequent girders were fitted in, girder to girder, in the same manner, the invert being cut out in sections of from 2 feet to 4 feet at a time, and the laying in of the girders kept as close as practicable to the taking out of the invert, so as to guard as much as possible against the risk of the water breaking through from the dock.

After the girders were laid in, bolted, and secured, they were filled up with concrete, and a surface course of hard composition brick, on bed—all beaten in flush with the upper webs of the girders, and ran in with Roman cement.

The girders when completed (except the girder at the middle, which forms the sole for the batter-doors), weighed 67 cwt. each, and measured 30 ft. 6 in. mean length, 2 feet in breadth, 12 inches in depth at the middle end, and 21 inches in depth at the extreme ends. They were made to the length in three pieces—the middle-piece 21 feet in length, the one end-piece 6 feet in length, and the other end-piece 3 ft. 6 in. in length; which, on fitting the middle-pieces together alternately, end for end, gave a lapping of 2 ft. 6 in. on the sides of the girders, where they joined girder to girder. The three pieces forming each girder were fitted and bolted together, and the fitting stripes on the sides of the girders all planed or otherwise dressed quite fair throughout the length, and the girders were cramped together for drilling the bolt-holes, which were all broached out, and the bolts turned to fit. The depth of the ashlar, &c. removed from the entrance was 4 ft. 6 in., corresponding to the 12 inches in depth of the cast-iron girders put in, giving a gain of 3 ft. 6 in. in depth, and a depth of water throughout the communication of 18 ft. 6 in. at high-water spring-tides. Fig. 1 is a part plan of one half of the communication, showing the new bottom, with a portion of the girders clear, a second portion being shown partly filled with concrete, a third portion with the surface course of bricks, and a fourth portion as having the final coating of Roman cement. Fig. 2 is a transverse vertical section of the same, with the old invert building indicated by dotted lines on the one side, showing the gain in depth; and in Fig. 3 is a vertical section across the middle girder, forming the batter-door sole and the adjacent girders.

In order to get these works accomplished, a coffer-dam had to be constructed to dam off the water in the dock; and it was deemed most essential that the constructing of the dam should not deprive the trade of the passage through the junction basin and timber basin to the canal, for a longer period of time than was necessary for completing the wharf walls and the entrances. Also, as the walls of the dock are founded to such depth that they stand on the mud under the till-bed before referred to, it has been held to be unsafe to run the water out of the dock, whilst it was feared that the driving of piles for making a coffer-dam in the usual way might endanger the safety of the walls; and, looking at the difficulty of driving piles in from 20 to 24 feet depth of water, and the subsequent difficulty and risk of making a secure and tight dam between two rows of piles, the wrought-iron coffer-dam was designed and made as represented in Figs. 4 to 9.

The dam is wholly made of wrought-iron; the framework is formed of nine girders, each girder 40 feet in length, 4 feet in depth at the middle, and 21 inches in depth at the extreme ends; the bow sides of the girders being made to a radius of 80 feet, and the string sides to a camber of 3 inches. The girders are made of angle-irons, all rolled in one length to the span of the dam, and the girders, Nos. 2, 3, 4, and 5 from the bottom, have web plates (also rolled in one length to the span of the dam) fitted between the angle-irons, which form the bows and strings. The sections of the parts of the girders decrease in size from the girder No. 1 at the bottom, to girder No. 9 at the top of the dam, and the spaces between the girders increase from bottom to top, so as to make the strength of the dam nearly uniform with the pressure of water due to the depth. The bottom of the dam is framed of T-iron ribs, and covered with ⅜-inch plates, all curved outwards to strengthen the bottom against the pressure. The girders are plated all over outside, the plates on the back of the dam all upright, the upright joints butted and joined by covering strips, and the longitudinal joints lapped and rivetted on the girders. The plates on the front of the dam are in lengths of 25 feet for the middle of the dam, and in such breadths as to lap the plates on the two girders for joining longitudinally, and the upright joints of these plates are joined by covering strips double rivetted by ½-inch rivets. All the other rivets are ⅝-inch rivets, pitched in at a distance of 2½ inches between centres along the rows which require caulking, and 5 inches between centres for the other rows of rivets. The plates vary in thickness from ⅜-inch at the bottom of the dam, to ¼-inch thick at the top. A sluice tunnel, 18 inches square, passes through the dam, with a draw-sluice on the back of the dam for shutting off or running water through the dam, and a pipe of 6 inches diameter, with a two-way tap-cock in the pipe, is fitted to the front and back of the dam near the bottom, for running water into or out of the dam. By this pipe and tap-cock the dam was filled for being sunk, or emptied for being floated, or the height of the water in the dam regulated to the height of the water in the dock. The whole weight of the iron-work in the dam, tunnel and pipe, is 20½ tons. The strengths of the parts of the dam were calculated to support a pressure of 20 feet depth of water, but the greatest height of water ever on the dam was about 19 feet.

The dam was made at Maryhill, and was launched into the Kelvin dock at three o'clock one afternoon, towed to Grangemouth, and set to its place, and the water run off from behind the dam on the following day. By filling in about a boat-load of tan-bark and ashes round the back of the dam for safety, and for compensating for the inaccuracies in the fitting of the dam to the wall, the dam was made as tight as could be wished, and remained so until the works were ready for its removal; when, by running the water out of the dam, and filling the basin (31st October, 1860), the dam rose from its seat and was floated out of the way, giving an immediate free thoroughfare for again passing the shipping between the dock and basin.

THE EXHIBITION OF THE SOCIETY OF FEMALE ARTISTS, 53, PALL MALL.

THIS, the fifth exhibition of the society, occupies, as it did last year, the rooms of the New Society of Painters in Water Colours, which it completely fills, and with a very acceptable collection of pictures. To these, certain remarks which we have made on former occasions will be found again to apply, but there is a steady improvement perceptibly going on, which leads to the expectation of still greater successes. Miss Louisa Rayner, who enjoys a well-earned reputation for her architectural delineations, appears to have essayed a greater breadth of treatment of late, to the ignoring often of details, which she, beyond most female artists, knows how to interpret. But in this quality there is another hand whose productions evince great skill and fidelity—that of Miss Isabella Jones, who sends four pictures, all of decidedly architectural character, and handled with considerable freedom. That of "Old houses at Conway" (200), and the "Fountain at Rouen" (256), are particularly noticeable. Miss Rayner produces several scenes from Roslyn Chapel; and Salisbury, Glasgow, Canterbury, &c., have again attracted her pencil. Lady Belcher is again a contributor. Her "Furness Abbey" (119) is not so successful as "Hereford Cathedral" (147). Mrs. Higford Burr, one of the most delightful and pains-taking artists in her particular line, sends but one picture (150), a view "in the Chapel of Sacro Speco, Subiaco;" in which the frescoes on the walls are very carefully expressed.

Among more general subjects we may point to (178) "Drawing of animals in chalk" by Mdlle. Rosa Bonheur, and the four bronzes (328—331) of cattle subjects, by the same artist; also two clever small pictures by her sister Juliette Bonheur; the clever marine-pieces by Mrs. E. Dundas Murray, to whose exertions as the secretary the society is so much indebted: Mrs. Murray's (of Teneriffe) powerfully depicted scenes; two by Mrs. J. T. Linnell; several by Miss Margaret Gillies; others by Miss Florence Peel; and (205) "a study" (of flowers) by Miss Charlotte James, to which the "national medal" was awarded.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Discussion on the Preservation of Stone.

A SERIES of special meetings has been held at the Royal Institute of British Architects, at the instance of Mr. Tite, M.P., for the discussion of the various processes for the preservation of stone from decay. Mr. Tite opened the discussion, and Mr. Digby Wyatt, the Vice-president, on the three evenings devoted to this subject, occupied the chair.

Mr. Tite gave a very detailed account of the various processes, and expressed his own opinion of the non-success of the applications in each case. Both in opening and closing the discussion, he denounced the processes of M. Szerelmey and Mr. Daines.

Mr. Burnell, after speaking warmly in disfavour of M. Szerelmey's Zopissa—which he said he had gathered in exfoliated scales that had fallen from the walls operated upon, and, in older specimens, had brushed off in clouds with his hand—stated that he knew of no process to which he could pin his faith or reputation.

The Hon. W. Cowper, M.P., said that, having the custody of the Houses of Parliament, as First Commissioner of Works, he was most anxious to avail himself of the united experience of this Institute. That when he came into office, Sir C. Barry had recommended the process of M. Szerelmey, but that, on extended trial, it was found not advisable to proceed with its further adoption.

Mr. George Gilbert Scott stated that he had tried all the various processes upon the Abbey at Westminster, but all had proved failures in a greater or less degree. He good-humouredly chided M. Szerelmey for falsifying the character of his process, and finally stated that no system had yet gained his confidence.

Mr. Warrington—who stated, in reply to the chairman, that he was engaged professionally for Mr. Ransome—said a few words in support of the process on which he had been employed.

Mr. C. H. Smith, one of the commission appointed to select the stone for the Houses of Parliament, entered rather fully into the circumstances under which he became attached to that commission, and the steps that were taken for the selection of the stone; further remarking upon the negligence of the authorities in not appointing an overlooker properly to inspect the stone as it left the quarries. Certain changes had taken place in the spots from which the stone was obtained, which at last varied to the distance of six miles from the locality originally fixed upon. He had himself been offered the post of supervisor, but had not been able to discover a responsible paymaster. Had this been done, the stones so notoriously bad would not have been used in the building.

Prof. Ansted, in support of his colleague Mr. Ransome, said all that could be said in extenuation of the failures of his process, for the most part attributing them to unfavourable circumstances during the manipulation; but also venturing to suggest that some stones could not be preserved from decay, when decay once set in, by any process whatever. He acknowledged the state of things to be very unsatisfactory, and suggested that the matter be referred to a committee of scientific men for a more thorough investigation.

Mr. Godwin gave some facts in the shape of negative evidence. He had witnessed the failure of Mr. Daines' process of sulphur and oil on a statue in front of the Foundling Hospital, which, after many attempts to preserve it, had fallen into such a state of decay that it had to be placed in the hands of the painters. He had the testimony of Mr. Calder Marshall to the complete failure of the process. He inveighed against the disfiguring of the Houses of Parliament by the inventors of so-called preserving processes, some few of whom had raised an agitation to suit their own purposes, and had gone far towards irremediably spoiling the characteristics of that superb building.

Mr. Ferrey spoke in favour of soft soap and alum, as being so cheap that its price would compensate for its frequently required application.

Mr. E. Barry exonerated his late father from imputed blame in the employment of Szerelmey's Zopissa on the New Palace; stating that qualified authorities had preferred this process to Mr. Ransome's, whose process he considered a failure, but the specimens of which he had now labelled on the building, so that anyone might have an opportunity of inspecting the result for themselves.

Prof. Hofmann stated his opinion on the process of M. Fuchs; but confessed that, beautiful as was the theory of the system, it was not suited to the humid atmosphere of England. He stated his objection to Mr. Ransome's process, which even as a theory he had pronounced a failure, as silicate of lime formed by precipitation of silica by calcium had no chemical affinity whatever with the constituents of the stone, and formed no union with it. He concluded by suggesting that the silicic ether, of which he had given a clear description, might be experimented upon to advantage.

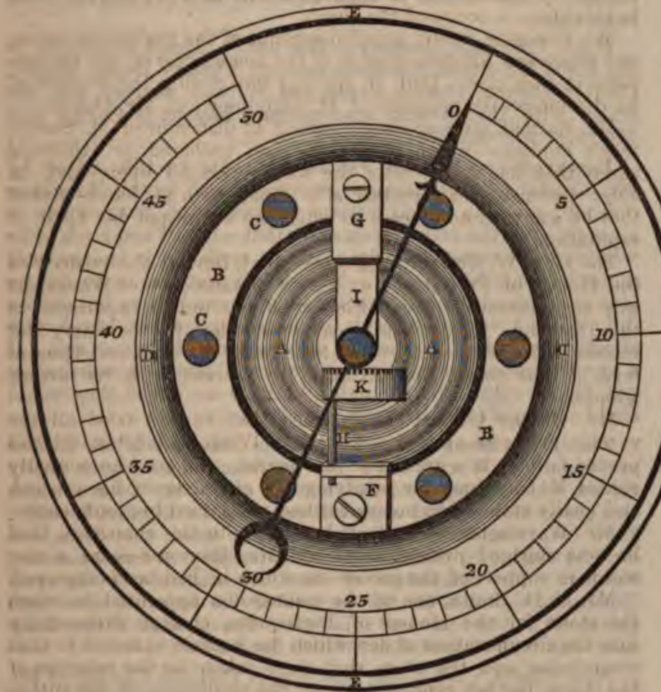
Dr. Frankland, who in accordance with a previous request of Mr. Godwin stated that he was professionally employed by Mr. Ransome, spoke of the silicate of lime process; and ended by saying that, as the price of silicic ether was six guineas per lb. it could hardly be used for the purpose required.

Prof. Tennant coincided with the opinions of Prof. Hofmann on the subject principally under consideration.

After some further remarks from other speakers, the motion proposed by Mr. Godwin and seconded by Mr. Tite was carried unanimously,—that the First Commissioner be requested to stay further proceedings at the New Palace at Westminster, and to form a committee of inquiry into the present state of decay of the building, and the best mode of arresting its further progress.

THE GOLD-DISK STEAM OR VACUUM GAUGE.*

By Richard Adie.



A. Corrugated disk of an alloy of gold, which covers the front of the small chamber.

B. Stout ring of gun-metal.

C. Series of six strong screws, which make the ring of gun-metal bind down the disk thoroughly steam-tight to the chamber.

D. Piece of brass in the form of a dish, which is fitted tightly on the edge of B, and secured in its place by a series of screws not seen in the drawing. The outer part of D, where the dishing ceases, is used as a plate for graduating the scale of pressure upon.

E. Groove turned in D to receive a glass face, which, after careful fitting, is sprung in with heat.

F. Cock to carry one end of an axle H.

G. Cock to receive the other end of the axle H; also to carry another cock I, in which the finger turns on a vertical axis.

H. Axle stretching across the face of the disk, carrying on it a portion of a crown-wheel K. A spur from the axle H is in connection with the centre of the gold disk; a knife-edge similar to those used in balances, communicates the motion of the disk to the axle and crown-wheel.

The finger in the drawing carries on its axle a pinion which pitches into the crown-wheel K, so that any motion of the disk is shown by the finger on the dial.

In order to prevent what is termed "drop" in the pitching of the wheel and pinion, there is applied to the vertical axis a cylindrical spring of brass or gold wire.

A bent tube, in the form of the letter U, is used to connect the chamber of the gold disk-gauge to the boiler; this tube is filled with water. The use of this connection is to prevent steam reaching the chamber, and so to keep the disk at a moderate temperature, which ought never to exceed blood-heat.

⁂ A subsequent improvement in the box or chamber of this gauge is, to bind firmly together the two inside surfaces by a spiral spring of gold in the centre. The requisite strength in the disk is thus obtained with less weight of gold, and the degree of elasticity is higher.

The gold-disk gauge originated through a liability to corrosion which was found often to spoil the gauges which the author was in the habit of supplying to a railway company.

About sixteen years ago, M. Vidi invented the aneroid barometer, and a steam-gauge, where corrugated metal disks were employed to measure changes of pressure. The patent was dated October 1844. M. Vidi's patent has expired, and it is believed that his invention is open to be applied to other forms of steam-gauges; although there are two subsequent patents still in force where the claim is made; in the first, to a chamber covered with any elastic material; in the second, to a chamber covered by an elastic metal. Of the value of these rival patents the author was unable to give an opinion: but if the claim to the general principle had to be discussed, it is doubtful if even M. Vidi would be allowed the priority; the late Mr. Macnaught, of Glasgow, having so many years before introduced steam into a chamber, where he measured its pressure by its action on a spiral steel spring.

Among the noble metals the author sought for a corrugated disk to measure pressures, which would not be destroyed by water: his thoughts were long turned to platina; but the metal of an old gold pen happening to be near, he was struck with the manner in which it had retained its form through a long period of service, and where the ink, as an agent for corrosion, must have been as active as oxygenated water, to which steam-gauges are exposed. The opinions of two friends who had had much experience in working the alloys of gold, confirmed him in the selection of this alloy for a gauge of vacuum or pressure.

The accompanying woodcut represents the front view of a gauge where steam pressure is introduced into a small chamber by a pipe at the back.

---

* Read before the Royal Scottish Society of Arts.

NOTES OF THE MONTH.

New Graving Dock for Birkenhead.—At a recent meeting of the Mersey Dock and Harbour Board, it was resolved to construct a very large graving dock at Birkenhead. Its length is to be 750 feet, width 85 feet, and depth 100 feet. It is to be large enough to accommodate two rows of ships, and to be so constructed as to admit two ships at a time. Its cost is estimated at £84,000.

Warming Railway Carriages.—A method of warming railway carriages has just been introduced on some French railways, involving only a trifling expense. The waste steam from the engine, instead of being allowed to escape into the air, is conducted from the escape-pipe of the engine, by means of a vulcanised india-rubber tube, to pipes through which it circulates under the seats and throughout the carriages. As soon as the train is set in motion the steam commences to circulate through all the systems of pipes, and warms the carriages—first, second, and third class—equally; and, being connected with each other by india-rubber tubing, they can be immediately detached or reunited at pleasure. In a trial on the Lyons line, two thermometers placed in first-class carriages marked 60° Fahr. during the whole journey; and in the second and third class carriages the temperature was sufficiently elevated to allow of the longest winter's journey being accomplished without discomfort. However cold the carriages may be when at rest, as soon as the train is started the steam commences to circulate through the tubing, and communicates an agreeable temperature to the whole train.

The Archæological Association has just settled upon its place of meeting for the present year, having accepted an invitation unanimously voted to the society by the Town Council of Exeter.

The International Exhibition of 1862.—The Royal Commissioners for the Exhibition of 1862 have addressed a letter to the Council of the Society of Arts, in which the following statements occur:—"The most pressing point was the building required for the Exhibition. In 1850, notwithstanding the possession of considerable funds, and the assistance of the most eminent architects and engineers, seven months elapsed before a design was adopted. The Commissioners therefore felt that, if they postponed the consideration of this subject until they were a legally constituted body, the cost of the building would be greatly increased, and a serious risk incurred of its non-completion by the appointed time The arrangements made by the Society of Arts, when negociating for a site on the estate of the Commissioners of 1851, and their announcement that the Exhibition was to include pictures, a branch of art not exhibited on the former occasion, rendered it necessary to contemplate the erection of a building in some parts of a more substantial character than that of 1851. A plan was submitted to the Commissioners by Captain Fowke, R.E., who had been employed by her Majesty's government in the British Department of the Paris Exhibition of 1855. This design was adapted to the proposed site, and was intended to meet the practical defects which experience had shown to exist both in the buildings in Hyde Park and in the Champs Elyseés. It appeared well adapted for the required purposes, and its principal features were of a striking character, and likely to form an attractive part of the Exhibition. The Commissioners submitted the design to the competition of ten eminent contractors, four of whom took out the quantities. Three tenders (one a joint one from two of the contractors invited) were sent in on the day named in the invitation, but all were greatly in excess of the amount which the Commissioners could prudently spend, with a due regard to the interests of the guarantors. The Commissioners have therefore had under their consideration modifications of the plan, which, without destroying its merits would materially reduce its cost."—It is understood that the Royal Commissioners came on the 23rd ult. to a resolution as to the precise character of the building required, and that as soon as the guarantee has been signed to the required amount, so that the Bank of England (who it is understood have offered very liberal terms) can advance the money, the Commissioners will probably enter into a contract with Messrs. Kelk, and Lucas Brothers, the two firms who sent in the lowest tender, and who have jointly agreed to execute the works. The only event in which there can be a call on the guarantors is a loss by the Exhibition, the liability of the Commissioners in respect of the building being limited to £200,000.

The Recent Floating of the Ship Queen Victoria.—The following are the details of the operation:—Two portable steam-engines had been taken on board the vessel, and arrangements made for driving two of Gwynne's pumps, which were put into operation at 11 o'clock a.m., and found to work successfully. The cascades which poured from the sides of the ship gave evidence of the efficiency of the pumps. The diver went under the vessel, and on finding the openings through which the water was admitted to the hull, he shoved in some felt, which stopped a portion of the influx, and it was then found that the pumps were nearly equal to discharging the water as fast as it came in. The engines were put to their speed, and the race between the pumps and the leakage continued with increasing prospects of success, and at five o'clock the vessel was actually afloat. At six she was taken into deep water, and was afterwards grounded upon shingle. In this position she is being repaired sufficiently for conveyance to the Plymouth Great Western Docks.

Ancient Remains in Ringmore Church.—In the east wall of the north transept, two windows, hitherto blocked and concealed on the outside by rough-cast, and inside by plaster, but now opened, have proved it is said, to be of very early Norman, or more probably Saxon date, closely resembling the acknowledged Saxon windows in Tintagel Church, Cornwall. Externally they are very short and narrow, and have semicircular heads. Internally they are splayed to a great width and height. Another window was discovered between them which had been cut through the wall, apparently in the fourteenth century. This portion of the church is believed to be between 800 and 1000 years old.

Royal Hibernian Academy.—The newly elected architects to the Royal Hibernian Academy are—Sir Thomas Deane, Messrs. Charles Lanyon, Patrick Byrne, and William Murray, who, together with the present academicians, Messrs. McCarthy and Mulvany, will constitute the quorum.

Preservation of Wooden Fences.—A paper on this subject by Mr. Cruikshank, of Marcassie, as reproduced by the *Banffshire Journal*, gives in detail various experiments, from which it appears, as in the author's summary that—1st. When larch or fir wood is to be exposed to the weather, or be put in the ground, no bark should be left on it. 2nd. When posts are to be put up into the ground, no earth should be put round them, but stones. 3rd. When a wooden fence is to be put up, a No. 4 or 5 wire should be stretched in place of, or alongside, the upper rail. If a proper larch fence were put up, or larch posts for wire paling put in, as suggested, he adds, "I have no doubt they would stand a lease of nineteen years."

The Luther Monument, Worms.—The Commitee of the Luther monument at Worms have just published their fourth yearly report, which states that two statues out of the twelve which this grand monumental work will comprise, Luther and Wycliffe, have been completed by Prof. Rietschel's hand; they have been sent for casting to the Einsiedel Art-foundry, at Lauchhammer, Saxony. The completion of three other statues of the early Reformers, destined for the corners of the pedestal, have been promised in the course of this year. The expense of the monument has been estimated at 200,000 florins.

New Church, Cork.—The new Roman Catholic Church of SS. Peter and Paul, Cork, the foundation stone of which was laid eighteen months ago, is rapidly approaching completion. The style is Franco-Gothic of the thirteenth century. The plan is cruciform, and consists of nave and chancel, north and south aisles, transepts, chapels, a tower and spire 232 feet high at the north-west angle, and a small porch and baptistery at the south-west. The nave is 127 ft. 6 in. long, 35 feet wide in clear between the columns, and the height from the floor to the ridge is 87 ft. 9 in. The nave is lighted from the clerestory by nine 4-light windows. The chancel is polygonal in form, and is 35 feet by 17 ft. 6 in. in clear. The roof is open-timbered and panelled. All the shafts in the arcade are of red marble, with bases of polished black limestone. All the arches and spandrils of nave are of Caen stone. In the spandrils will be statues, life-size, of the twelve apostles, in Caen stone. The exterior walls are of red sandstone, with limestone door and window dressings. The cost of the building, exclusive of the tower and spire, is estimated at £11,000. Messrs. Pugin and Ashlin are the architects. Mr. Barry McMullan the contractor.

ON ARCHITECTURAL COMPETITIONS.

As the profession of architecture is at present constituted, there is no subject so much needing mature consideration and inviting concerted action as that of competitions. Upon some members of that profession this presses as a matter of personal and of vital importance. They employ themselves habitually, or at least occasionally, in public or other competitions; and the irregularities, difficulties, injustice, and uncertainty that beset architectural competition, as ordinarily administered, are to them a constant source of injury and discomfort.

Others, and those the more influential members of the architectural body, are by their position placed above the inducement to take any personal share, except occasionally, in such proceedings, and may be hardly conscious sometimes how much damage those evils, the immediate reach of which they themselves have outgrown, can inflict, not merely upon the rising generation of architects, but upon the profession, and its position in the eyes of the public.

It will be attempted to prove that a series of unfortunate circumstances ordinarily attend architectural competitions, the removal or palliation of which is quite practicable, and ought to be attempted; all the more because great benefits have arisen to the profession from the recent extension of competition: and it will become a matter for anxious inquiry whether means cannot be found for securing the greater portion of these benefits, while yet the ordinary modes of procedure may be so altered as to diminish the concomitant evils.

This subject has been brought before the public so frequently, both by the architectural societies and the professional press, that it may well be considered difficult to approach it without the risk of saying over again that which has been already published. It is, on the other hand, to be remarked, that as all that has hitherto been said and written has led to nothing, the only course left is to return to the subject, and, if necessary, to urge once more what has been already stated fully and fairly, in the hope of being able at last to educe a tangible result.

Before entering upon the abstract question of competition, or the practical one of how to regulate it, and how to enforce any regulations that may be determined upon, it may be well to examine the actual condition of the question, particularly as it affects public buildings; for it is a significant fact that, frequent as are the competitions for the design of buildings of a public character, and the management of which rests in the hands of a committee, a vestry, or a board, it hardly ever occurs that designs are invited in competition for private works of the same or even of much greater extent.

The position of the subject at the present day may be stated to be as follows:—In the case of certain classes of buildings, the public, finding that a very considerable number of persons, professing themselves to be competent to design and superintend works, are always desirous to be employed, and willing to go through a considerable amount of exertion to obtain employment, have habitually taken advantage of this circumstance to procure for themselves the opportunity of having several designs to pick from without incurring any expense or liability: sometimes with the honest desire to secure the best design; sometimes in order to dispose of the solicitations of several rival candidates for the proposed work; sometimes in order to screen the appointment of some relative or favourite to whom it would not be possible, without scandal, to give the work in a straightforward way; and sometimes, perhaps frequently, from custom only.

On the other hand, the case of the architects is, that in large numbers they accept these invitations, and sooner than lose what seems to offer an opportunity of obtaining practice, they incur expenses that they cannot afford, as well as undergo exertions which, although in moderation they may no doubt prove beneficial, are but too often excessive. As the object kept in view by competitors must necessarily be, not so much the production of the best design, but of the one that may be thought the best by the persons who have to decide, and as an expensive and elaborate system of finish and brilliant colouring are believed to be essential to procuring the approval of the class of persons who ordinarily do decide, the result is that a needless amount of finish is invariably given to these drawings; and experience having shown that persons unaccustomed to buildings almost always select the design that promises the greatest amount of work and of the most ornamental character for the smallest sum of money, it has come to pass that an estimate, which is spoken mildly of when it is termed inaccurate, more usually than not accompanies many of the sets of designs. Finally from the whole nature of the case it constantly happens that temptations are held out to underhand dealing of various descriptions,—temptations which but too often prove greater than those to whom they suggest themselves can withstand.

On the other hand, in a brief statement like the present of the general bearings of the question, it must not be omitted that competition possesses the advantage of offering a mode of settling the selection of one out of several candidates where there are conflicting claims. It holds out too a possibility of obtaining in country places, where the local architects may not be great artists, the chance of procuring modern ideas, and the design of an architect educated more highly than the men of a past generation sometimes were.

To the young architect it offers an opportunity of distinguishing himself by his own skill and abilities; in spite of a lack of powerful patronage, it seems to hold out to him the possibility of procuring practice; and it affords him an opportunity of acquiring skill and experience in the difficult art of mastering a new subject, and designing a structure to meet varied requirements. Last, but not least, it affords him employment during that period of enforced and unwilling leisure which in all professions ordinarily intervenes between the close of preliminary studies and the successful prosecution of responsible business.

Let us examine some of these advantages more in detail. And first we will consider the benefits just enumerated which fair public competition offers to the class of architects who most frequently engage in it. Of these advantages, probably the most solid are the opportunities thereby afforded for exercising the power of design and arrangement, and for employing leisure hours. It is worth encountering much disappointment, and making many apparently fruitless efforts, to acquire the education which a young student receives in some of the most important parts of his profession from a series of competitions. He is aware that his efforts will be measured against those of men who will take great care to render themselves familiar with every detail of the subject to be treated—be it a hospital, a barrack, the largest public institution, or the most simple and unostentatious structure—and he is thus driven to practise himself in the art of collecting and utilising information, and is amassing stores of knowledge, and skill to use them, which may in after years prove invaluable.

Again, the preparation of a design for a large building, complicated as it necessarily sometimes becomes, is a matter with which a student ordinarily would not voluntarily busy himself; and he will find the mere management of a large set of drawings a matter in which much is to be learned from practice, and which it might prove disastrous to approach for the first time under circumstances where a blunder might produce incalculable injury to some actual structure. Real improvement in drawing is also likely to be obtained by the competitor, for he knows that his plans will have no chance unless they are prepared in a style as effective as that adopted by others; and upon improvement in drawing, improvement in power of design is sure to attend.

It is then unquestionably better that a young man who may have nothing to build, or may have not enough fully to occupy his time, should have these opportunities of exercising himself; and that, without the heavy anxiety and remorseless demands upon time for matters unconnected with architecture, which a large building brings with it, he should enjoy the advantage of exercising himself in the treatment of the most important and difficult problems his profession can afford. It is also at the time, and so far as personal advantage goes, a far better thing to be fully, even excessively employed, than to be left waiting in a silent office till business comes in. More men no doubt have pined and sickened under the anxious pressure of hope deferred during the dreary period of waiting for practice at the bar, than ever over-wrought themselves at the architect's desk; and a system which lightens the pressure of this care, inevitable in a country where all the professions are crowded, does no small good.

On the other hand, each advantage has its evil, young men are apt to let competitions stand in the way of their regular business, and injure themselves by expending their time and energy upon these when they ought to be attending to the affairs of their clients, or extending their professional connection; this evil however may fairly be left to cure itself, as after a little experience in each instance it probably will. A more serious injury is inflicted on the profession by the ease with which the offer of a very small money premium brings forth a large series of elaborate designs, and the consequent depreciation in the eyes of the public of the value of an architect's labours. The barrister in this particular reaps the advantage of his abstaining from non-remunerative business. The public look upon him as a man whose labour is worth his fee, and who will not work without remuneration. They pay him consequently cheerfully and liberally, and they value his services accordingly.

It cannot be quite so in the other case. Suppose a committee of business-men who desire to expend £2000 on a building, wish for complete designs, and find that an architect will prepare them a design only, exclusive of working drawings and specification, for a moderate commission—say 1½ per cent. or £30. They subsequently resort to competition, offer a sum of £20, divided into two premiums; and receive from twenty to forty or fifty elaborate sets of drawings, including an aggregate of labour so great, that if the premium were rateably divided among all who have worked in proportion to the time they have spent, it is not too much to say that there would not be enough to remunerate them at the rate at which paupers are paid for breaking stones at the roadside! Can we wonder if the managers of an undertaking like this hold the services of an architect very cheap; when if you approach the profession privately, and require a design from an individual, he requires £30; while, if you invite designs publicly, you find the same profession are willing to furnish them for the ostensible price of one fiftieth chance of £20? The proper remedy for this misfortune, so far as a remedy can be applied, we shall point out further on; but it must be admitted that the ease with which drawings can be elicited in reply to any sort of invitation, has very much tended, and must tend, to damage the standing of the architectural profession.

The advantages of what is called "the generous emulation of talent," and the opportunity of procuring business such as would otherwise have been inaccessible, may be apparently greater, but they are not after all so real as those now brought forward. It sometimes happens that a competition of more than ordinary interest calls forth from unknown men designs of astonishing promise, and from others well before the public, works so full of genius and studied excellence as to show that the occasion has stimulated the authors in no common degree. This was perhaps the case with the late competition for the Government Offices, and certainly occurred in the most interesting of recent competitions—that for the Memorial Church at Constantinople. But every architect knows that the most talented works are in nine cases out of ten to be sought, not among the premiated but among the unsuccessful designs in any competition; and the knowledge of this must have, and has its influence, in causing men to aim rather at meretricious and taking effect than solid excellence of design; and however the excitement and haste of competition may sometimes rouse an artist to the production of a brilliant, striking work, there are few who would advance the opinion that architects' best designs are those hastily produced to encounter the uncertainties of competition, rather than those maturely prepared with the consciousness that they are to be carried into execution, and that upon the success or failure of the building they represent is staked the reputation of the artist.

The idea of obtaining practice must of necessity be more or less illusory, from the mere number of competitors to be encountered in each instance. But were this all, these uncertainties would be greatly diminished in the case of an accomplished artist. It is rather the uncertainties that beset the decision of competitions, and the various other drawbacks (to which attention will next have to be directed), that reduce the prospect of gaining employment by competition to one often very little, if at all, better than that of gaining employment by private influence and connection, upon which the competition system was supposed to be an improvement.

(*To be continued.*)

FOREIGN PUBLICATIONS.

Among the most useful architectural works published in France may be mentioned one, extensive in its scope and satisfactory in the mode of its execution, which yet is not so large or so costly as to be excluded from any tolerably good library of architectural works. We allude to "*L'Architecture Civile et Domestique du Moyen-Age et de la Rénaissance*"—a comprehensive work, including specimens of the domestic architecture of the middle ages in other countries as well as in France, and so carefully executed as to be of great practical value. The authors, M. Verdier and Dr. Cattois, were impressed with the desirability of preserving some record, as well as publishing some account, of many of the fine examples of civil architecture which the middle ages and the time immediately succeeding them have left us; for the security is wanting in their case which the circumstances of ecclesiastical buildings in some sort present against the risk that at any moment the caprice or convenience of an owner, or even the unchecked ravages of time, may not entirely remove from the face of the country any one of the remaining fragments of the domestic architecture of past days.

Nothing can be more instructive than to compare the secular architecture of any period of the Gothic or pre-Gothic time with the church architecture practised at the same moment, and for this the volume before us gives ample opportunity. Italian mediæval palaces and houses are illustrated by a considerable number of well-chosen examples, and so also are the monastic buildings of France. In some cases, where almost all else has perished, the "grange," or barn and adjacent buildings belonging to a monastery, have, from their great solidity and size, remained comparatively intact. Of these beautiful examples from Meslay, Vauclair, and some other similar buildings are given here. But perhaps the most interesting series is one of mediæval dwelling-houses and shops, especially those from Cluny. A small plan of the curious town itself is given, with the situations of all these buildings marked, and their date also indicated, and a selection of the best examples—which by the way commence as early as the twelfth century, and reach down to the sixteenth—are illustrated by elevations, with details and descriptions.

The plates in this book, as in most French works on architecture, are such as the English student will appreciate more than the letterpress with which they are accompanied. Still the letterpress, though including various things that it would not have perhaps been a great loss to have omitted, is not without value; while the plates, which are mostly elevations, carefully executed and well shaded, are very useful. Details are given in abundance, and some of these are of great beauty, and so well engraved, that though they are not to a very large scale, they may be held to be intelligible enough for any practical purpose. Altogether this work can be heartily recommended, and the more so because a large proportion of its examples are of early character, thus giving specimens of at once the best period and the one from which fewest remains have descended, and respecting which information is in consequence least generally accessible.

A portion of another work, upon a much larger scale, and only partly published, has been brought under our notice,—it is the "*Monographie de la Cathédrale de Chartres,*" the issue of which was commenced several years ago under the auspices of the government. This work, as its title imports, is entirely devoted to the graphic delineation of one monument, the well-known Cathedral of Chartres. Such a building can well afford materials for a work upon itself alone; and it is the peculiar merit of French architectural publications that they are very apt to take up a single building, and give plans, general elevations and sections, and details enough to enable the reader to form a very good idea of the nature of the building as a whole and of its minute parts.

These plates of Chartres, which are wonderfully executed, and of large size, include plans at various levels, with other geometrical drawings, enlarged elevations and sections of some of the architectural features, plates showing some of the stained glass windows, and a series of illustrations, exquisitely drawn in perspective, of the marvellous sculpture with which this building is enriched. We have become familiar through photography with the noble portals of the great cathedrals of France; but it is difficult from any photographs, except such as represent single figures and groups, to form so accurate an estimate of the beauty of such sculpture as that at Chartres as these engravings enable us to make. Whether we look at the beauty of the sculpture as adapted to the architecture, at the skill and grace of the draperies, or at the character, force, and individuality of the countenances, we find in each case occasion to admire afresh the perfection to which for a brief period the art of architectural sculpture attained.

For those who have much occasion to study the method of treating the human figure necessary to produce perfect accessories to Gothic architecture, whether in relief or for glass painting, this work cannot fail to be of great value; while it will interest all lovers of Gothic art by its clear and complete delineation of one of the noblest of French cathedrals. It is right to add that the architecture, ornamental sculpture, and painting on glass are by Lassus; the statuary and mural painting by Duval; and that descriptive letterpress from the pen of that well-known archæologist, M. Didron, is included in the programme of the work. No portion of this letterpress has however yet been brought under our notice, and we believe none has been published. The whole work at present is a splendid fragment; but even if left incomplete it could not fail always to command admiration, and to be regarded as an architectural book of the highest class.

It will be probably desirable to return to this work in a future number, as the collection of examples of stained glass merits a separate and more extended notice.

COLOUR AS APPLIED TO ARCHITECTURE.

By Sydney Smirke, R.A.

(*Concluded from p.* 68.)

What, then, are the principles that should guide us in the treatment of colour in external architecture?

1. Whatever colours may be used, they should not be so used as to detract from the harmony and unity of the general effect. For this reason violent contrasts are seldom attended with good results; when such strongly marked contrasts are not offensive, it is when they are uniformly spread over a whole composition. Thus, when in a red brick building stone dressings are used throughout for the quoins, window jambs, cornices, strings, &c.; or when on an exterior of red bricks there are reticulations of black bricks over all the plain surfaces; these strong contrasts of colour do not offend the eye, because of the intimate and general intermixture of them: the only effect is, that in the one case the light stone dressings lighten the effect of the building, and in the other case, the dark reticulations being disseminated over the whole, lower the tone without disturbing the unity of the building. But scatter those white stones or black bricks here and there, sparsely and at irregular intervals over the front, and the general effect will assuredly become spotty and disorderly.

2. In the distribution of coloured materials regard should be had to the retiring and advancing qualities of colour. Thus white, and bright yellows and bright reds, appear to stand forward, whilst black, blue, and greys retire. Care should be taken not to outrage these prejudices of the eye; for example, when dark and retiring colours prevail at the lower parts of an architectural composition, and the upper parts are of bright-coloured materials, the latter will inevitably appear to advance and overhang the former, producing a false effect that cannot be agreeable. So, when buttresses are built of a darker stone than the intervening wall, they seem to sink into instead of advance from the face of the wall; and the eye gets puzzled and offended, for an effect is produced at variance with what we know to be the fact. For the same reason, I have seen a very bad effect produced by a black marble frieze introduced in an order built in other respects of light-coloured materials. When viewed at some distance, or with half-closed eyes, the cornice seemed suspended in the air, or at all events the means of its support were not obvious; and generally we may regard it as a rule in matters of this nature that constructive doubt and uncertainty produce an unpleasing impression, like that produced by the concealment of the feet of figures in a picture. So also dark marble columns in front of a light wall, unless brought out by polish, or by a considerable depth of shadow behind them, lose that prominence and æsthetic value which should belong to them; reverse the arrangement and all ambiguity vanishes, each part then takes its right place in the composition, and the eye consequently rests satisfied. It ought not to be necessary to dwell on a principle that appears, I think, so obvious; but it is too certain that the principle, obvious as it may be, is often lost sight of.

3. Special care is needed in the introduction of dark bands and other features of like nature, that they do not interfere with the architectural shadows of the composition. Nothing, perhaps, in architectural design is more important than to preserve its outlines and masses distinct and unambiguous; and as those outlines and masses are best brought out and rendered intelligible by shadow, whatever interferes with the due force of those shadows must detract from the effectiveness of the work. There is great danger in using those dark streaks and chequered courses which are now gaining so much favour, lest the shadows of the building in which they occur should lose their value. For, when not seen so near as to allow of a clear perception of details, these bands are hardly distinguishable from shadows. However easy it may be to cite old examples as a justification, reason ought ever to prevail over precedent. I know that these zebra stripes occur in many parts of the peninsula of Italy and in Spain, as well as elsewhere in Europe and in the East. As I have already said, they may have originated in some constructive requirement, no doubt adding to the strength of the wall. We have no such valid reason to urge in favour of our dark streaks; at all events they constitute, I think, one of those eccentricities of the past which scarcely deserve to be disinterred.

4. There is another principle of paramount importance in the treatment of colour in exterior architecture—viz. that the colouring should be consistent in character with the purposes of the building itself. Our ancestors correctly appreciated the cheerful character of white, by frequently designating halls erected for festive purposes "Whitehalls." The hall at Kenilworth Castle was called the Whitehall. There was a Whitehall in the Old Palace of Westminster; and the Whitehall of Charles's intended palace is familiar to us all. There is also a Whitehall in the royal palace at Berlin. Even our cousins across the Atlantic have taken over with them the tradition, and they have their Whitehalls for festive and popular gatherings. It is a fact, not without interest to any true born Londoner, that the lofty building called the White Tower, in the mediæval citadel of this port of London, seems likely to owe its name to having beeen whitewashed externally. In a very fine illuminated manuscript of the fifteenth century, preserved in the British Museum, a carefully executed view of London is introduced, in the foreground of which appears this great fortress, and while the general masonry of the building is coloured naturally, and in a somewhat low tone, the tower, with its four angle turrets, stands out prominently and conspicuously white. So marked is the distinction that it cannot have been so represented in the manuscript without a special purpose, which was probably that of identifying the building.

If, as I have said, white is calculated to produce in the mind a cheerful impression, black, on the other hand, has ever been viewed in an opposite sense. Thus, from remotest times, black was typical of mourning. *Atra* and *lugubria* were synonymous words. Even the sacred rhapsodist, when he would describe a scene of terror and despair, says, "All faces gathered blackness." The same distinction is alike applicable to those colours which, on the one hand, partake of the character of light, and those which, on the other hand, are characterised by an absence of light. It is not for us here to inquire whether there may not be physical causes assignable for this mental phenomenon: but that the animal spirits may be raised or depressed by the mere contemplation of different colours—that colours, according to this quality, may be productive of positive pleasure or pain, irrespective of any considerations of harmony and discord, are facts within the reach of every man's experience, although probably it is beyond the reach of human intelligence satisfactorily to explain them.

The power of colour to produce strong emotions of the mind has been at all times recognised. Thus, when the sacred writer desired to raise in the mind a picture in the highest degree poetical of the Holy City, he represented that the building of its wall was jasper, and its foundations as being garnished with sapphires, with chalcedony, emerald, and all other stones of resplendent colours; the gates were of pearl, and the streets of pure gold. No doubt the value and rarity of these precious substances were also calculated to excite the imagination; but their beautiful colours were evidently an important ingredient of the vision. Sometimes our admiration of an object is excited by describing it to be "like unto a jasper," or "to a sardine stone," or even "to a rainbow." The Bible is indeed full of evidences of the high appreciation of colour as a source of beauty and pleasure. In the Homeric writings also we may find abundant evidence of this natural and pervading feeling. Azure and vermilion are constantly used as typical, as it were, of regal splendour. No doubt every classic scholar can greatly extend these illustrations. I will not detain you with quotations from Chaucer, Spenser, and others of our poets, in whose minds rich colouring seems ever to be associated with ideas of magnificence.

I do not know how far I shall have been justified in so long a digression; but I trust that I have at least established enough to warrant me in saying that the poet, of whatever country or age or creed he may be, will be always found to regard colour as an important means of raising in the mind an image of beauty or magnificence. I am very sensible that there is a vast, an almost incalculable difference, between the works of the poet and of the architect. The one has but his imagination to draw upon, whilst the other has to seek the materials of his work from a very different source, and too bold a draught upon his imagination would be the likeliest means of bringing his career to an untimely end. Still there is an analogy—remote it may be, but real, and I think manifest. I have said that I regard it as a principle of our art in the treatment of colour in exterior architecture, that the colouring shall be consistent in character with the purpose of the building itself, and I have adduced various notable instances of the adaptation of colour to the nature of the building. The subject is indeed fruitful. I might easily adduce abundant proof to show that, as bright colouring has ever been regarded as productive of a gay and cheerful effect, so dark and sombre hues are equally effective in raising feelings in harmony with the grave and serious purposes of some buildings.

This indeed seems obvious. Who would not be at once struck with the excessive impropriety of bright coloured decorations on the exterior of a prison, or a cemetery, and may I not add too of a church? For however becoming it may be to lavish on a building destined to the service of God all the best offerings of art and genius, I am by no means convinced of the propriety of chequering over the exterior of a church with bits of bright coloured materials. Even in the interior of a church it is, to my mind at least, open to question whether a true religious feeling is not better expressed by the grey, sombre tints of old stonework, than by the gorgeous pageants of gilding and painting, inlaying and polishing, by which piety is supposed by some to be measured. Beautiful as are the St. Chapelle and the Church of St. Généviève, at Paris, and the Hof Kapelle at Munich, it is impossible not to regard them rather as æsthetic triumphs, than as evidences of the devotion of the builders. It is very long since I saw the Church of St. Maria Maggiore, at Rome, prepared for the midnight ceremonies of Christmas-eve; but I have a vivid recollection of the enchanting effect of the bright polished marbles and the gorgeous gilding, the crimson satin embroidered banners and the green festoons; yet the impression produced on my mind was that I saw before me the most elaborately beautiful *salle à danser* in the world.

It is, I repeat, a principle of paramount importance that every building should be conformable in the character of its architecture to the nature of the purposes to which it is destined. There is in the treatment of colour in exterior architecture yet another consideration which must by no means be overlooked—viz. that treatment should always be influenced by the site of the building. The *genus loci* must be consulted. The strong positive red of bricks, for example, extending over any bulky object, presents an unpleasant contrast when surrounded by green foliage; and when these bricks are of a dark, dingy tone, they sink into the landscape, and the building, as such, loses proportionately its value. For this obvious reason stone is a very preferable material; we must all have often had occasion to observe how a white building brightens up a landscape—how the white cottage sparkles in the distance when set off by the surrounding deep green tones. It is true these white buildings may cease to be so pleasing when they occupy too much space in the eye—a great white mansion is always best seen when half-concealed by foliage; and this may suggest more artificial modes of subduing the intensity and breaking up the monotony of these large white masses. For this reason the intermixture of stone and brick is often far preferable to the use wholly of one or the other. But the use of two qualities of stone, the one of lower tone than the other, is perhaps a still more unobjectionable measure, provided the difference in tone be not too violent.

In civic architecture other special local considerations have to be taken into account. There are in towns seldom any pleasing natural accompaniments to assist us. House is opposed to house—each has to contend with the damaging effects of its neighbour. In fact, our most frequented streets present for the most part a very inharmonious medley of sizes, forms, and colours,—like a Dutch concert, where each performer, it is said, plays his own particular tune. Still, it is very questionable whether even this scene of confusion may not be regarded as less objectionable than the insipid uniformity of some modern German towns—such as Stuttgard, for example, where it would appear to be almost impossible for a man to know his own house from his neighbour's, unless assisted by some private mark or some familiar badge. The severest military discipline seems to pervade even the architecture of the town, and the houses are drawn up in array, like soldiers on parade. We might say of them—taking a little liberty with a well-known text—

> "House nods on house—each column has a brother,
> And either terrace just reflects the other."

Such dull uniformity seems to me more offensive than the most tumultuous disorder.

In the architecture of towns and cities we are seldom called upon, as in rural situations, to subdue or neutralise any excessive whiteness. In the large towns of England, at least, soot soon clothes the nakedness of a new stone building, and too effectually lowers its tone. This might suggest the expediency, in such a climate and with such an atmosphere as ours, of avoiding the use of any coloured material of too low a tone. Those who have seen Schinkel's elaborate work in deep red terra-cotta—the Bauschule, at Berlin—will have regretted that so much intricate and beautiful workmanship should result in producing so ponderous an effect. Light loses its quality of brilliancy, and shadows lose their force and distinctness, when the façade is veiled, as it were, in this monotonous deep tone.

I think then that it will be admitted by all, that a certain amount of variety of colour in a piece of architecture of any considerable extent adds to its power of pleasing, by giving it spirit and animation. But it is in this as in most other matters dependent on human judgment: the greatest difficulty—that which is the real touchstone of talent—is to know where to stop, and to determine how far to carry this variety of colour. In some towns on the Continent we see washes of green, yellow, red, and other gaudy colours used to an almost ludicrous extent; and in nothing does the Asiatic origin of a large portion of the population of Russia show itself more than in their love of gaily-coloured architecture, both domestic and ecclesiastical. At Moscow, near the Kremlin, is a church dedicated to St. Vassil, whose fantastic and indescribable architecture is rendered still more barbaric by the brightest colouring up to the very summit of its highest towers. The bulbous shaped domes that in singular profusion surmount the towers of the adjacent palace, or group of palaces, designated the Kremlin, glitter with gold and paint; whilst the iron roofs throughout the city seem all to be green or red. In their country houses too I hear of an excessive use of bright greens and reds. These are it is true the excesses ever attendant on an uncurbed, uncultivated taste; but perhaps on that account they the better illustrate the natural tendency of all minds, both the wise and the simple, to derive pleasure from colour.

Let us however be moderate in our indulgence of this pleasure, and let us be discreet in the manner as well as in the measure of our indulgence. My own predilections are certainly in favour of almost limiting the varieties of colour on the outside of a building to those which are afforded by the natural hues of the materials themselves. I feel averse to resort in exterior architecture to the use of artificial colouring, except for temporary or experimental purposes, when of course the practice is quite admissible; but I would never willingly resort to painted external decorations as permanent work—if indeed any work so executed can be called permanent. Where oil is the chief vehicle adopted for the colour no doubt it resists the weather for some time, even for many years perhaps, although its purity and brilliancy may speedily depart; but if oil-painted decorations be objectionable for their deficient durability, how infinitely more so are the ephemeral decorations of other pigments. I well remember, when at Munich, my great concern to find that, by casually leaning against the wall of a great public building, I had transferred on to my coat no inconsiderable portion of its Pompeian ornamentation. I hope we shall never be driven, by the urgency of other demands on the public purse, to resort to such means of beautifying our public buildings. There, at all events, let our colours be natural. Nor will this obligation impose on us any inconvenient limits. Nature is rich in coloured materials of various hues; we have in common building stones a wide range, from red sandstones to chalk; and our marbles are almost endless in their variety of colour.

I would however except from this condemnation of artificial colouring one most important source of beauty. I refer to those earths that, by burning and vitrification and by chemical processes, are brought to the condition of naturally coloured substances. There need be no apprehension as to their permanency; they will outlast most stones, and their colour never fails. I have already adverted to the use of this artificial material, and I now only remind you of it to show what abundant means we possess of colouring our architecture without resorting to the paint-brush and to the wash-pot.

I have now touched upon most of the salient points of the subject to which I have appropriated this evening. I feel too well aware how little can be effected within the narrow compass of a single lecture; but I believe the value of such remarks as I may address to you depends wholly on their suggestive nature. Whatever truths there may be in the thoughts expressed, they are wholly inert and valueless unless they are made by you the groundwork of further thoughts, and excite in your mind a desire to pursue further the inquiry into the subjects touched upon. The seed that falls upon barren ground will take no root, and be productive of no good result; whilst that which falls upon good ground is at once kindly received, and springs up and brings forth fruit, some twentyfold, some fifty, and some a hundredfold, according to the richness of the soil, and to the care of the husbandman.

To quicken the energy, to smooth the path, and to facilitate the progress of the really studious learner, is the anxious desire and aim of this Academy. You will accept this my assurance, that the student who in his earnest exertions to improve himself shall seek such aid and advice as I feel myself competent to give, will find in me no grudging or unwilling, but rather a most ready and cheerful adviser.

◆

THE EXHIBITION OF 1862 VIEWED IN CONNECTION WITH ARCHITECTURE.

It is gratifying to observe that the architectural societies are beginning to direct the attention of their members to the necessity of taking care that their Art be worthily represented in the Exhibition of 1862. The Architectural Association have passed unanimously a resolution to the effect that it is desirable that the various bodies of architects throughout the kingdom should co-operate to secure a good exhibition of architecture, and they invite other societies to lend their aid, expressing at the same time their own readiness to take their share of the duty. A few days later, at the Royal Institute of British Architects, it was announced from the chair that the matter had already long had the attention of the council; and it was requested that members would favour the council with their suggestions. It now remains to be seen first whether the various provincial societies will respond to the call thus made upon them by their London brethren, and then whether any active and concerted measures cannot be brought about worthily to accomplish this end.

Never was there a time when the interests of architecture in this country could have been so well served by a great public exhibition as now they can; and never, perhaps, was there so much worth exhibiting as has been recently produced in this way—certainly never since exhibitions began. We have just revived our national style of architecture. The noble pile at Westminster, which must always remain a central monument of that revival—as St. Paul's will mark the culmination of the Classic Renaissance amongst us—is but just completed; and now that we are launching on an era of novelies, tentative efforts, adaptations of foreign features, and striving after a new and a characteristic manner of building, it behoves us more than ever to keep together, and to embrace every opportunity of looking at one another's works, and trying to harmonise our various procedures and methods of design.

The great progress that was made in the best times of the middle ages rose from the fact that all men were then working in a common direction, and the efforts of the individual tended to advance the progress of the community. Have we not too far departed from this practice in the present day? and, with all our facilities for travelling, our public societies, and our professional journals, does not England alone present tenfold the amount of division that Europe exhibited in the matter of architecture in the thirteenth century?

If, without any sacrifice of the right of private judgment, or any loss of the spirit of design in individual artists, we could only manage to fuse our efforts into something approaching a united move in one definite direction, we might hope to advance rapidly towards a style worthy the name of "Victorian Architecture" —a title of great pretension, and which the public is just now being called to apply to the works of a very markedly *sectarian* section, if the word may be allowed in a secular sense, of the modern school.

Nothing could better contribute to this progress, and could more awaken the public mind to the value of good architecture, than an exhibition by means of drawings, models, photographs, casts, and all possible methods, of the best works of architecture that have been executed or designed and worked out for execution during the last few years. We even believe that if the best works only of the two schools which have alternately enjoyed public favour, could be collected and exhibited in chronological order, much more unity of purpose among the leading members of each school, and much more assimilation between the two schools, might be traced than at first sight appears.

The course of the Gothic Revival began in antiquarian research, and was continued by progressive efforts, each tending to produce a more correct reproduction of some past detail or style than before; it then, advanced to the mastery of its materials, began to design, although only within the limits of archæological propriety; and now, seeking its manner of working in all styles—Continental as well as British—and procuring its material from all sources, those unfolded by modern skill and science no less than those hallowed by ancient precedent, it is making daily progress. This course, we repeat, intelligently represented, would exhibit a far more consistent and steady progress than has been by many supposed to have characterised it, and would probably be much aided in its future advances by such opportunities for reviewing its past history.

No less would the less connected thread of the history of Classic architecture, commencing from where we replaced the architecture of the Parks and Regent-street by attempts but partially successful to imitate the inimitable finish of Greek art; from which we were led back by Cockerell and Barry to those adaptations of Italian art which in their refinement and dignity combined must always rank high among the architectural achievements of the century:—no less would a series demonstrating this history grace the walls of an exhibition where Englishmen ought to teach themselves and show to others their real position in the history of the fine arts of modern Europe.

No effort ought to be left untried to secure a fine collection. Probably the best hope is from a series of photographs of buildings themselves, illustrated when practicable by photographic reductions of plans, sections, and other architectural drawings. But it is to be hoped that such photographs will be on a much larger scale than the very moderate dimensions with which our English photographers seem contented, and in which they quietly allow themselves to be surpassed by both French and Italians.

Photographs alone however will not suffice; good views, of which an enormous number exist in the possession of architects, will, if faithful, be of great value; and so above all will models. A model, and a model only, shows the perspective changes that manifest themselves on walking round a building, or (when the model, like that of Wren's design for St. Paul's, now at South Kensington, shows the interior also) in passing through it. Such changes are as much a part of the artistic excellence of a building as the complete grouping of a piece of sculpture when viewed on all sides is a proof of the sculptor's skill; and on this ground, if on no other, the exhibition of architectural models ought to be encouraged.

Lastly, all this requires time. There exist or can be created abundant materials for the formation of such a gallery as we wish to see; but the discovering them, and arranging and preparing for their reception, promises to be a more difficult and lengthy task than that of arranging the preliminaries for an exhibition of paintings. We therefore hope that no time will be lost in making a good commencement, and in following it up with energy and determination.

◆

BRIDGES OF CAST STEEL.

We extract the following from *Nouvelles Annales de la Construction*, a French periodical, to which we shall have occasion again to refer:—

> "In proportion as materials are perfected and rendered more homogeneous, it becomes possible to extend the general dimensions of the objects manufactured from them, and at the same time to diminish the relative section of their component members, so that the materials support a greater number of pounds weight per superficial inch."

After showing the great superiority in actual strength possessed by cast steel over cast and even over wrought iron, the writer continues—

> "For some years past the manufacture of cast steel has been extended in a remarkable manner. Considerable manufactories have been established for this object, both in England and on the banks of the Rhine, and even in France. But wheel tires, springs, axles, rods for pumps for mining purposes, cannons, and some other special applications, have been the only products which, up to the present day, have been manufactured in the course of trade. Why should not the execution of bridges and roofs of great span be attempted in cast steel? It is only the first step which it is difficult to take in any sort of progress. When one application of this material has been made, it is more than probable that the success of it will be followed by others; and then we shall soon see engineering works executed to span rivers, valleys, arms of the sea, more vast and more daring than those hitherto familiar to us. Spans of 200 or 300 metres (650 or 1000 feet) will become ordinary, and will present no other difficulty than that of fixing."

◆

NEW CHURCHES.

There are now twelve new churches in progress in London and its suburbs, and several others projected. One now in progress, situated in Baldwin's-gardens, at the rear of the eastern side of Gray's-inn-lane, from the great merit of its design requires particular notice. The neighbourhood in which it stands is one of the most immoral in the metropolis, and where the benefits of religious instruction are specially needed. A portion of the sacred edifice occupies the site of the once notorious "Thieves' Kitchen." This large, costly, and peculiarly-designed church is now in an advanced state, the exterior being nearly completed, together with a parsonage and sexton's house on its southern side. Brick is employed in the construction of the walls both externally and internally, there being no plaster used internally except in the aisles and beneath the large west windows of the nave. The arches and columns are of stone, the latter having moulded caps and bases of highly effective section. We did not perceive, in our brief survey of the interior, a single sculptured enrichment of any kind introduced. The interior of the church is exceedingly imposing, arising from its great height (81 feet); and already produces a warm and pleasing effect by the judicious introduction of coloured brick, in red and black horizontal bands, and lozenge-shaped forms. The eastern half of the chancel, both east end and side walls, is to be lined with alabaster; that on the eastern wall divides itself into large panels, in which are to be painted various subjects, beginning from our Lord's Nativity, and ending with the Day of Pentecost, in the upper compartment. The interior faces of the walls of the north and south aisles have arcades formed on them by a series of pointed arches, supported by red Staffordshire clay shafts, standing clear of the recessed walls, producing an admirable effect: similar shafts also carry the nave roof. The spandrels between the arches are relieved by deeply sunken moulded quatrefoils. The constructive timbers of the roof are seen. The walls have horizontal bands of red brick and stone, diversified with chequered work in red, the general groundwork being yellow; the whole producing a highly pleasing impression, without the coldness of either stone or plaster. The edifice possesses many of the admirable peculiarities of treatment and detail usually introduced in edifices of this kind by its architect, Mr. Butterfield. The contractor is Mr. George Myers. The church is expected to be consecrated about the middle of the coming summer. It has been erected at the sole cost of Mr. J. G. Hubbard, M.P., whose praiseworthy act will, we trust, be very successful in improving the moral condition of the inhabitants of the district.

A fine church is in progress in Hanger-lane, Stamford-hill, from the designs of Mr. J. Talbot Bury, architect. The style is Early Decorated Gothic. The materials employed are Kentish rag stone for the plain walling, and Boxhill Bath stone for the dressings, and portions of the tower and spire. The church is cruciform in plan. The nave is 73 feet long by 23 feet wide, and 53 ft. 6 in. high from the floor to the ridge; the aisles being of the same length, and each 12 ft. 6 in. wide. The eastern end of the chancel is semi-octagonal, and on its northern and southern sides are a vestry and organ chapel. The tower, which is 18 feet square externally at the base, is placed at the south-western corner; it will be 60 feet in height, surmounted by a well-proportioned spire, which, when complete, will give a total height from the ground of 125 feet. The principal entrance porch is at the north-western corner. The nave is separated from the aisles by a series of pointed arches. The chancel will be somewhat elaborately decorated in colour. The mouldings of the internal pillars, shafts, and arches, are all of stone. The roofs display their constructive timbers, which, with the open ornamental seats, are to be of stained deal. Attached to the church will be a commodious parsonage, finished externally with brick facings, having characteristic stone dressings. The contractor for the whole of the works is Mr. Myers.

The foundation-stone of the Church of St. James the Less, Upper Garden-street, Westminster, was laid in the spring of 1860: the structure comprises a nave, side aisles, north and south transepts, and chancel. The roofs of the chancel and apse are groined in stone and brick. Three pointed arches on each side divide the nave from the aisles, the voussoirs of which are formed in black and red brick. The walls are lined to a height of 4 feet with Minton's encaustic tiles, and the floor of the chancel is laid with coloured tiles in geometrical pattern. The total length of the interior in the clear is 94 feet, by a width of 51 feet. The apse is circular in form, having a diameter of 20 feet. The tower is 20 feet square, and carried up to a height of 87 feet, surmounted by a spire, 45 feet high, of timber covered with slate. This edifice is of brick and stone both outside and inside, although in some instances more costly materials are introduced, as Devonshire marble for the columns, &c. The carvings in stone are of a most elaborate and characteristic description, finely rendered by Mr. Pearse. The structure was designed and is being executed under the superintendence of Mr. G. E. Street; and is, we understand, erected at the sole cost of two daughters of the late Bishop Monk. Mr. Myers is the contractor.

The church of St. Mary, Hornsey Rise, of which the foundation-stone was laid on the 29th of June last, is now in an advanced state. The plan of the edifice is cruciform, and comprises a nave, chancel, north and south aisles, and transepts. The tower is at the south-west angle. The plain facings of the external walls are of Kentish rag, and the doorways, string-courses, copings, tracery, labels of windows, and quoins of the supporting buttresses are of Bath stone. The style is Decorated Gothic, of the fourteenth century. The church has been erected from the designs and under the direction of Mr. A. D. Gough, architect; the contractor being Mr. G. J. Carter.

◆

ON GAS ENGINEERING.*

By David Laidlaw.

The importance of the branch of engineering relating to illuminating gas will be freely admitted, when it is stated that the estimated capital employed in the manufacture and distribution of this now most necessary source of artificial light is upwards of £30,000,000; and to this large sum must be added the capital employed in mining and conveying coal, in iron and brass founding, and in the various branches of business in connection with these, which give employment to many thousand individuals. Again, when we take into consideration the immense demand for artificial light, and which could not have been supplied had we still to depend upon oil and candles—the estimated quantity of coal consumed being about 3,500,000 tons, and the income derived from gas £5,000,000, annually—it is evident that this is a branch of engineering that requires careful study and attention; whilst the more thoroughly the manufacture of gas is understood the better and cheaper will it be supplied to the public.

---

* Read at the Institution of Engineers in Scotland.

Gas light is comparatively a modern invention; for, although inflammable gas issuing through fissures from coal or other carbonaceous matter has been known from the earliest ages, and although a few experiments had been made on coal gas as early as the beginning of last century, it was not until the year 1790 that Mr. William Murdoch (who at that date resided in Cornwall), having had his attention called to inflammable gas issuing from a neighbouring mine, made several experiments in distilling gas from coal, and in 1792 conveyed tubes through his dwelling-house and office, and was the first who succeeded in practically introducing this most invaluable discovery. In 1798 he lighted with gas a portion of the Soho works, Birmingham; and early in this century a few private works were erected for lighting manufactories. Comparatively little progress however was made in the extension of gas-lighting until after the year 1814,—no doubt owing to the many difficulties that had to be contended with in manufacturing and purifying the gas, and also to the cost and insufficiency of the fittings; but the great improvements that have taken place in all these departments, and which have also reduced the prices, have for many years past rendered it indispensable. Not only is it used in our large cities and towns, but also in palaces, country mansions, and dwellings of all classes; in our shops, warehouses, manufactories, and streets; and also in our manufacturing processes to a considerable extent. Nor is it confined to towns only, but many villages, some with less than a hundred consumers, possess it; and these works, when properly constructed and managed, yield not only a superior light at a cheap rate, but good dividends to the shareholders. Glasgow, as might be expected from the enterprising character of its citizens, was amongst the first to erect public gas-works. A charter was obtained in 1817; the works were constructed by Mr. J. B. Neilson, and for many years were managed by him.

It was suggested by our president, that the writer should in the present paper give his experience of gas engineering in St. Petersburg. As the contract there is not nearly completed, it will in the meantime be sufficient to mention that it embraces 600 retorts, with all the necessary purifying apparatus, steam engines, four telescopic gasometers, each 100 feet diameter and 40 feet deep, and two 60 feet by 40 feet deep, together with iron roofs, station meters, &c., and about 10,000 tons of main pipes, from 3 to 36 inches in diameter, besides many hundred lamp-posts. In September last a very successful start was made, and gas was distributed through upwards of 50 miles of main pipes chiefly those of the larger sizes. The city is built upon the banks of the river Neva—three canals intersecting the city. These have all to be crossed at numerous points, the pipes being taken below their beds. This is a tedious work. The inclemency of winter in that region requires to be duly guarded against: the condensers, purifiers, and every portion of the apparatus, including the gasometers, must be placed in houses, with the means of heating them. The pipes are all laid 5 feet beneath the pavement; and, as it is almost impossible in any part of the city to dig more than 4 feet without being inundated with water, the engineering difficulties are not trifling. But above all, the greatest difficulties to contend with are the theoretical opinions of the Russian military engineers; the delays in getting any matter decided upon, and the innumerable obstacles presented by those whose duty and interest should be to promote expedition; and also the very short portion of the year (about five months) in which out-door work can be carried on.

The first duty of an engineer on being employed to erect a gas-work is to endeavour to procure the most suitable site. This should be chosen at or near the lowest part of the town, and, if possible, should have communication with a railway, river, or canal, to lessen the cost of conveying coal and other materials into the works. Ample ground should be secured not only for present but future wants. The efficiency and economical management of many gas-works have been neutralised by selecting too small a piece of land, with the view of saving the cost of a few hundred yards of main pipes; and hence additional ground has to be secured at an enormous cost, or additional works have to be erected at an opposite side of the town, which necessarily greatly increases the annual charges by a double management and other expenses.

The next duty of an engineer is to arrange the various buildings with a due regard to convenience and economy in working. In all manufactories where the routine is daily the same a saving of much labour may be effected by proper arrangements, and the annual charges on the business consequently greatly lessened. In the plans made out by the writer for the works in St. Petersburg particular attention was paid to this. The coal stores were in connection with the retort houses; but the Russian military engineer, Col. von Okle, who was appointed for the building department, altered this arrangement, and placed the coal stores at a distance of twelve or fifteen yards; and the supply of coal has first to be deposited in these, and then wheeled across to the retort house for each charge of the retorts, thus entailing an enormous unnecessary annual expense.

The buildings should be constructed either of stone or brick, whichever is cheapest in the locality. A few years ago, when the writer contracted to light Gibraltar, the governor, Sir James Ferguson, allowed him to take all the stones required merely for the expense of quarrying them. A calculation was made of the cost of hewn-stone walls and cast-iron walls; and it was found that, although labour was nominally cheaper there, as in most places abroad, than in this country, it was in reality more expensive, on account of the small amount of work done; and that the principal buildings could be erected of cast-iron, of a more elegant design, and at less cost than with stone; and accordingly this was done. The writer has also, in erecting some works abroad, used cast-iron framing, and filled in the spaces with brickwork, which makes a very strong and durable structure. The retort and purifying houses should all have roofs with iron rafters covered with slates or other incombustible material.

The first portion of the apparatus is the retorts. These are made of various forms and different materials. Cast-iron was exclusively used for many years. Some engineers have used wrought-iron retorts, and Mr. King of Liverpool used some made of cast-iron with wrought-iron tops. During the last twenty-five years fire-clay retorts have been extensively introduced, and are now very generally used in large gas-works. The introduction of fire-clay retorts gave rise to much discussion between gas engineers on the respective merits of iron and clay retorts; but the writer has no hesitation in saying that no gas-work should have clay retorts, except those which have a sufficient number in use to pay the expense of keeping a steam engine and exhauster at work. Another kind of retort is built with fire-bricks: these are about 20 feet long, 5 feet wide, and 18 inches high. Retorts of this class however are used in very few works. The writer prefers the clay retorts for large works to be 18 feet long, 18 or 20 inches wide, and 12 inches deep, with a lid and ascension pipe at each end.

The construction of the ovens, and the number of retorts that should be placed in each, have also been much discussed: some engineers prefer three, others five, some seven, and others even as many as nine. Some engineers use clay and iron retorts in the same oven, but the great object is to carbonise the coal in the retorts with as little expenditure of fuel as possible.

In old gas works the ascension pipes and bridge pipes used for conveying the gas from the retorts to the hydraulic main seldom exceeded 3 inches in diameter, and were easily closed up. Now we make the ascension pipes 6 inches at the mouthpiece, tapering to 5 inches at the top, and the bridge and dip pipes 5 inches. Gas should not be retarded on its passage through the apparatus: all pipes and passages should be of ample capacity, with as few bends or knees as possible; and all knees should have flanges that can be taken off for cleaning the pipes.

From the hydraulic main the gas passes through a condenser, where it is freed of the tar; it then passes to the exhauster, a species of pump, which draws the gas from the retorts and forces it through the purifying apparatus, and thus reduces the pressure in the retorts. It next passes through the wash-vessels, or scrubbers, which free it of ammonia, and next to the lime purifiers, where it is freed of the sulphur. To the various methods of purifying gas it is unnecessary here to allude, whether by wet lime, dry lime, or a combination of both, or by the use of oxide of iron or other chemical substances. Wet-lime purifiers are now rarely used, in consequence of the inconvenience of the mixture of lime requiring to be kept in constant agitation: they also greatly increase the pressure, and there is great difficulty in getting rid of the lime-water. In consequence of these objections dry lime is now almost universally used. The most convenient arrangement of dry-lime purifiers is in sets of four, with the change valve in the centre so made that three purifiers are always at work, leaving the fourth disengaged to be prepared with fresh lime for use; each purifier is thrown out of use in succession, as the lime gets saturated with sulphur. In this arrangement the gas passes first through the foulest purifier, then the second, and lastly through the pure lime. Purifiers have been by some engineers enlarged to a most inconvenient size of late. Those vessels should not however exceed 12 feet square, whilst there should be a sufficient number of sets for the quantity of gas that has to be purified. From the purifiers the gas should in all cases pass through a station meter, which registers the quantity made, and from it to the gasometers or gas-holders.

In large works the gas-holders are now generally made telescopic, as they hold nearly double the quantity of gas that the single-lift holders do in the same size of tank; they are more economical in construction in proportion to their cubical contents, and occupy less ground. The largest gas-holder in Scotland, and that the writer believes has yet been in full operation anywhere, was lately erected in Glasgow, under the superintendence of Mr. Bartholomew, engineer to the City and Suburban Gas Company.

Tanks for containing the gas-holders are frequently a source of great annoyance and expense to gas companies, and in their construction the utmost skill of the engineer is often taxed. When the ground is firm, stone or brick tanks are easily made water-tight when well built, and puddled with clay carefully; but when the ground is soft or marshy, it is often next to impossible to construct them, except with iron; and when of large diameter the author prefers to make them on the annular principle: these do not require the entire diameter to be excavated, and a comparatively small foundation of concrete or other materials is required.

When making plans for St. Petersburg, the tanks, which are 102 feet in diameter, were designed on the annular principle, being best adapted for the marshy soil of that capital. The Russian military engineer already alluded to, however, insisted that he could make brick tanks for one-half the price of iron ones, and he was allowed to build one. The result was that it cost an immense sum more than the estimate for the iron one, and, being a complete failure, an iron one had to be placed inside of it,—a proof to the directors that Russian theory was much more costly than British practice.

A source of very great loss to gas companies is the condensation and leakage of the gas in the street mains. In some instances as much as one-third of all the gas manufactured is thus lost; and the writer believes that the average loss is not under 15 per cent., and in no case under 10 per cent., although some gas managers have stated a less quantity. This is a department which should have the engineer's careful attention, and much may be done to lessen the loss; but to bring it down to 1 per cent. is an impossibility, for a much greater loss must occur from condensation alone. The quantity and sizes of the pipes, in proportion to the amount of gas consumed, must also materially affect the amount of loss. When the towns are compact and the consumers close together, the loss will be smaller than when the consumers are scattered at a distance from each other, as often occurs in small towns. Much however can be accomplished to reduce the loss by the sizes and quality of the pipes, and the way in which they are jointed. When the main pipes are too small in diameter to give an ample supply of gas, a heavy pressure must be put on at the gas-holder to force the gas quickly through the pipes. The pressure should not exceed in level towns 1 inch of a column of water; but it in some towns exceeds 4 or 5 inches, the loss of gas increasing with the pressure. All sizes of pipes, from 1½ inch upwards, should be cast vertically in dry sand moulds; pipes thus made are free from pores, and the metal is closer in the grain than when cast in green sand, and on an angle or bank: for although the latter quality of pipes will stand the test of the hydraulic press, yet there is no doubt they do allow gas to escape through the pores of the metal. It is a well-known fact, that where gas pipes have lain for a number of years, the surrounding earth is impregnated with gas to a considerable thickness. Another cause of loss frequently arises from the pipes being made thin and light, and in some soils they are very soon corroded. This is false economy. The methods of jointing pipes generally adopted are those with spigot-and-faucet packed with hemp or rope yarn and lead, and spigot-and-faucet bored and turned joints. The latter kind, when properly made, have the advantage of being quickly laid, as the joints only require to be coated with red lead paint, and knocked home with a mallet. They make a very perfect joint.

The quality of the gas is a very important matter, and requires careful attention. The chemical tests are now well known and easily applied. On the quality of the coal depends in a great measure the illuminating power of the gas. Cannel coal yields the largest quantity and the richest quality. The price of gas should be regulated by its illuminating power. To compare the gas of one town with that of another by the prices charged per 1000 cubic feet, gives no true result, because the illuminating power of the one may be double that of the other.

Gases are sometimes tested by comparing their specific gravities; but as this may be affected owing to the presence of carbonic acid or atmospheric air, this method is not a sufficient test, and the photometer test is therefore preferred, as by it the quantity of light actually yielded is measured.

The meter by which the quantity of gas used by each consumer is measured and registered, is a most important instrument. Previously to its invention in 1816 by Samuel Clegg, recently deceased, each burner was charged for according to a scale of prices, and had to be paid for whether in constant use or not. With the meter the consumer only pays for the quantity of gas he actually consumes. This instrument therefore has been the means of greatly extending the use of gas. There are two descriptions of meters in use, generally known as "wet" and "dry" meters. The accurate registration of the wet meter is determined by maintaining the water at a fixed level. The legislature have had this matter before them for nearly two years, to the very serious loss of the trade, and have passed an act, which cannot be carried into operation, and which act has been suspended until further information is obtained. The arrangement of the front box of the meter was introduced by the writer in the year 1844, to obviate an objection that existed in nearly all meters, which was that the water could be raised above the true level, and thus diminish the measuring portion of the drum—to the loss of the consumer. In the meter referred to it was rendered impossible that the indication could ever be greater than the actual quantity passed through; and for this reason the City and Suburban Gas Company adopted it at the time they commenced business, and have since fixed upwards of 25,000. No gas can be extracted from these meters without being registered; gas companies may, however, be losers to the extent of two or three per cent. of gas, owing to the evaporation of water from the meter before the valve closes, but the public can in no case suffer. Mr. Allan, of Perth, took out a patent about eighteen months ago, to convert the space in the front box of the meter, above the water line, into a reservoir for water to supply the loss by evaporation. By means of tubes the water is taken from the reservoir to the back part of the meter, into the chamber in which the drum works, and supplies any evaporation that takes place. By a very slight alteration upon the writer's meter, he has, with Mr. Allan's concurrence, taken advantage of this reservoir, as shown in the meter exhibited to the meeting, and the simplicity of the arrangement will be observed. Several trials were made by Mr. King, of Liverpool, and the results were so satisfactory that he has adopted the arrangement. The Liverpool Corporation Inspector also made several trials on a five-light meter on this plan, the result of which was also very satisfactory; showing that, after abstracting 80 cubic inches of water, the registration only varied ·25 per cent.

◆

RAILWAY FROM ANCONA TO BOLOGNA.*

The railway from Ancona to Bologna constitutes the principal artery of the Romagnas (the Marches, Umbria, Emilia, and the former States of the Church). This line will on the one hand unite these rich and beautiful countries with Central Italy, Parma, Venice, Milan, and Turin, and, prolonged on the other hand from Ancona to Rome, it may become the principal thoroughfare of the future capital of the kingdom of Italy.

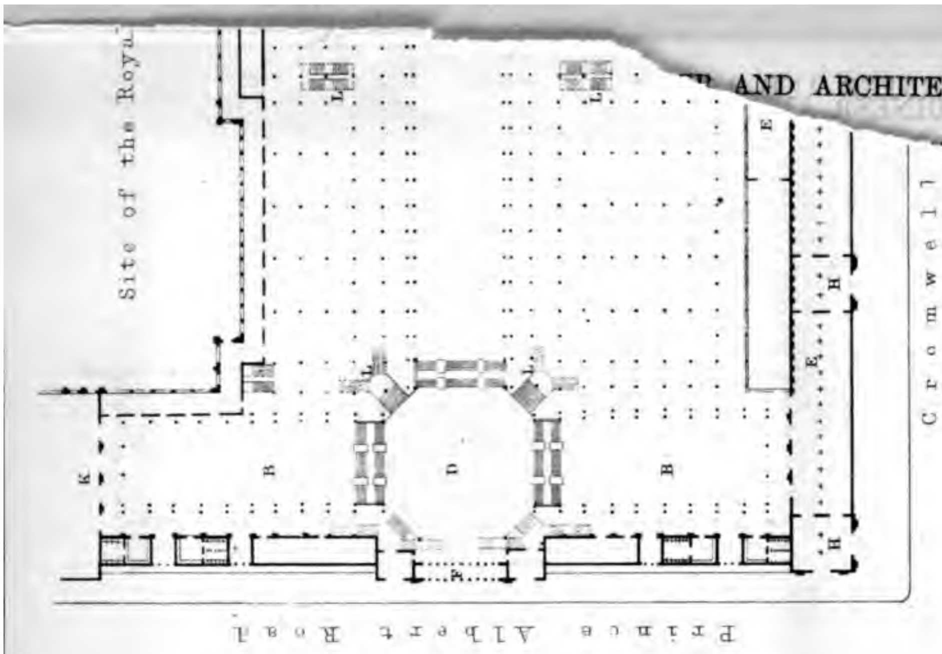
The earthworks and engineering works are making rapid progress. The stations and termini are commenced, and will be carried out by Messrs. Opperman and Co., on the economical models adopted by the railway company, in concert with the general contractor, S. de Salamanca. The whole series of

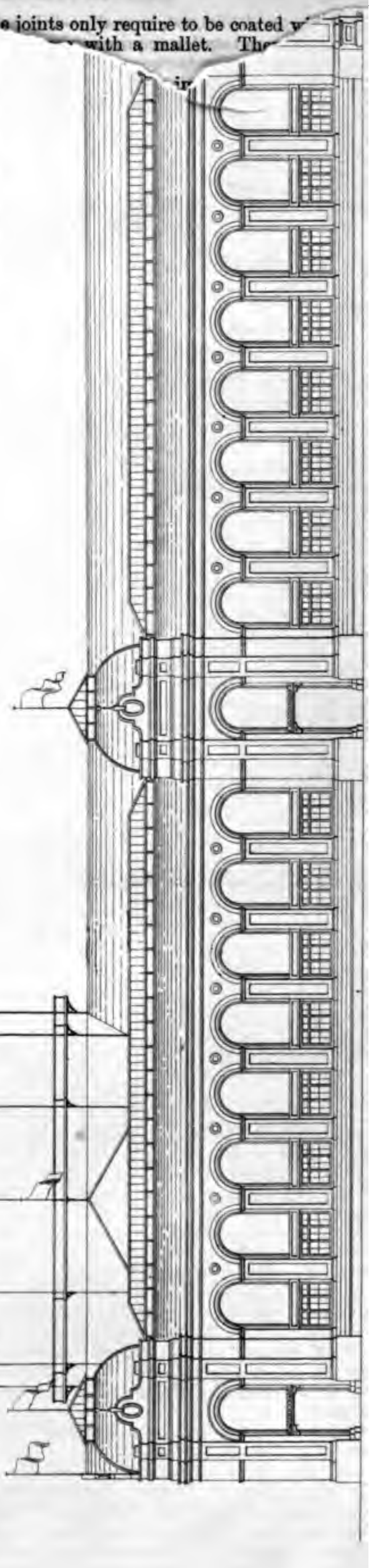
---

* From *Nouvelles Annales de la Construction*.

and stations compris
mpleted

the joints only require to be coated w
with a mallet. Th
ir



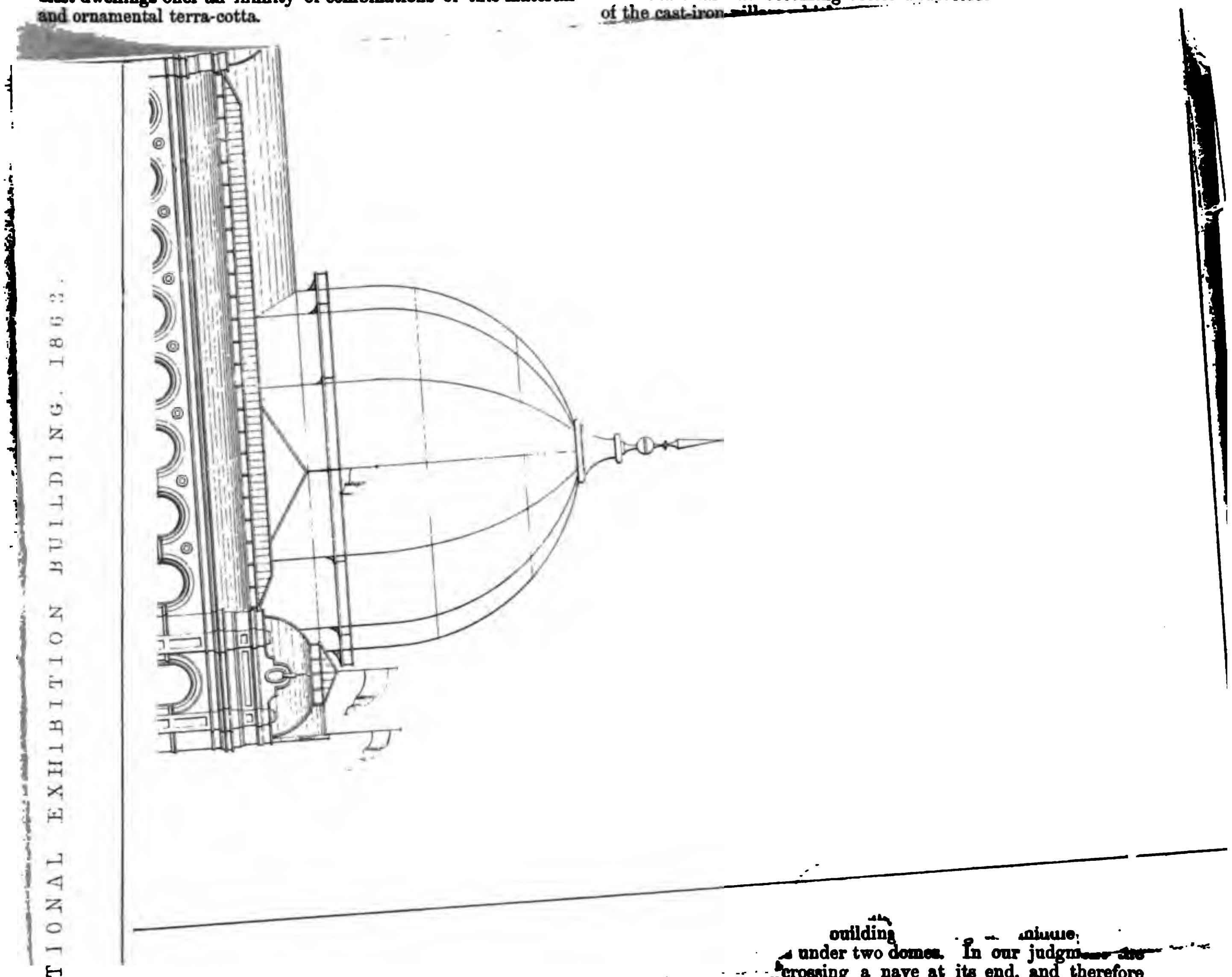


S. ELEVATION OF THE INTE

eighteen termini and stations comprises about 120 various buildings, which must be completed at most within one year. The general system of construction is of brick and hollow tile, with facings of cement and plaster in panels. The cornices and string-courses will be decorated in brick. The whole of these buildings will thus have a character quite in harmony with the architecture of the country, where all is brick, from the leaning towers of Bologna to the richest palaces, and where the humblest dwellings offer an infinity of combinations of this material and ornamental terra-cotta.

to be very small indeed. Probably, as is usual, the truth lay between the two extremes. The faults of the building, as it seems to us, consisted principally in matters of detail; and some of the details certainly displayed a deplorable want of taste. We are familiar with vulgarity in the architectural treatment of cast-iron; and the heavy ungainly forms which that material was made to assume in the great Hyde-park building gave no reason for hoping that the proper treatment of cast-iron as an architectural material was becoming better understood. The

of the cast-iron


TIONAL EXHIBITION BUILDING, 1862.

invention,

vantages arising from bringing large portions of the civilised world into peaceful intercourse with each other. The preparations for another like Exhibition in 1862 cannot therefore fail to command very general interest, and to the professional classes whom we address the construction of a building so vast, and having features so peculiar as must necessarily belong to a building of this kind, is an event of no ordinary importance.

Of course in examining the architectural character of the new building comparison with that of 1851 is inevitable. That building certainly received its full share, and more than its share of commendation. Influenced by the excitement of novelty or by the popularity of the Exhibition itself, many writers attributed to the building merits which a more sober judgment would have hesitated to assign to it. On the other hand there were some few eminent critics, including Mr. Ruskin, who thought the amount of taste and invention displayed in the building of 1851

building

under two domes. In our judgment

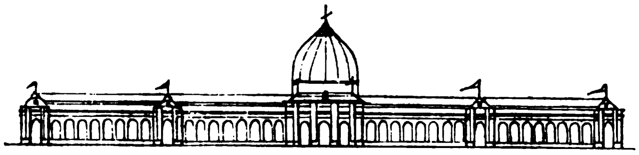
crossing a nave at its end, and therefore

views in only three directions, is likely to be far less imposing than that of a transept intersecting the centre of a nave, and there commanding views in four directions. And as far as precedents can be cited on such a subject, they are all in favour of this opinion. The cruciform disposition of the transepts is adopted not only in the Mediæval cathedrals, but also in a vast number of great churches in which the forms of Roman architecture are adopted, and in many of the most celebrated oriental edifices.

In the intended building the spaces beneath the two domes are octagons. The domes are proposed to be vast glass structures, 200 feet in height internally, and with the finials 250 feet externally. These enormous domes, exceeding in size those of St. Peter's and St. Paul's, have been regarded as among the best features of the design. To us they appear to be among its worst. In the first place, their position is indefensible on the ground of architectural taste or structural propriety. It is easy enough to call any structure ugly, or the reverse; and the misfortune in matters of taste is, that very frequently no better reason can be given for the judgment upon them than a certain perceptive faculty which the critic assumes (and frequently wrongly assumes) to be the same in himself and those whom he addresses. Much architectural criticism is of necessity addressed to this esoteric feeling or taste, and not to the reasoning faculties. But in the present instance we may very safely appeal to the latter. Consider for a moment what every dome or spire is intended to represent: it is nothing more than an elevated roof. We cannot doubt that the spires of our churches had their origin in the elevation of the roofs of towers. The tower of an old Norman church, instead of having a ridge roof like the nave, would naturally be covered in by a pyramidal roof with a low apex. These roofs were gradually built higher and higher, and the spire of Chichester, or Salisbury or Lichfield, was no more than a development of the low tower roof of which examples abound in our Norman churches. The same remark applies to domes both in Oriental mosques, and buildings like St. Peter's and St. Paul's. This then being the origin of domes and spires, we have to consider their necessary position. Universally—without a single exception in any structure of the slightest importance—the position of a dome or spire is upon a tower, or a structure answering the purpose of a tower. The spires of cathedrals are placed either on towers at the west end, or as at St. Paul's, on a drum or analagous structure rising above the main roof of the edifice at the intersection of the cross. That is to say, there is no instance of the continuity of the roof being broken by domes springing up as in the case of the proposed building from the level of the roof, in a place where no tower or structure analogous to a tower could be supposed to exist.

In the internal view of the building the position of the domes may appear to have some relationship (though imperfect) to the rest of the structure, for they are in the centres of the side aisles or transepts above mentioned. But in the exterior view the domes are altogether out of place, and seem to rise up suddenly where there is no conceivable reason to expect their appearance. Over the centre of the building in front, or even near the two ends of the front, they might be tolerated, but rising at either end of the building and to the rear of the front, they have no apparent relation to the structure, and no apparent means of support. It may we believe be safely asserted, that the proposed position of the domes is unparalleled in the architecture of any age or nation. Thus we have strong though negative evidence that the opinions and taste of all architects have been such as would condemn the design as to these domes.

If we admit for a moment that a dome of some kind is necessary, we cannot help thinking the proper position of it to be over the centre of the front façade, as in the following sketch, in which one of the domes of the form proposed in the existing design is supposed to be erected over that façade.



Of course in making this suggestion we are by no means to be understood to commend the design as so altered; we simply submit the suggestion as an improvement of it as it exists. We certainly should not wish to be understood as commending the form of the domes, which seems to us very ungraceful, or as advocating the erection of one of them. Confessedly they are useless—and will be enormously costly—and if our view as to their ornamental character be correct, there is no reason for erecting these prodigious "follies."

The front façade appears scarcely less objectionable than the domes. It is an almost unbroken surface of brickwork, 60 feet high by 1200 feet long, without wings or recesses. The only breaks of the continuity of the surface are the central and four side entrances, very slightly advanced beyond the face of the wall, and the series of blank arches. In a view of the building which has been published, the series of arched window spaces in the façade are represented as lights, but these spaces are really meant to be blank, except the lower part of each, which contains a common square window. In fact the façade is little more than a dead wall of enormous length, without any deep recesses or bold projections to break its monotony; and the only architectural forms which it presents are an interminable series of round-headed arcades and pilasters, and certain ornaments over the side entrances and the central entrance, the former somewhat after the Elizabethan style, the latter after no known style.

Add to this the consideration of the long, level, monotonous sky-line of the building, and the architectural reader will we think have reason enough to lament that the world is to be invited in 1862 to judge English architectural taste under the aspects here presented. A very able paper in the *Illustrated London News* of March 23, 1861, concludes by observing on the opportunities which this building might have afforded for the display of the architectural knowledge and taste of this country, and by expressing regret that those opportunities "have not been taken advantage of, and that in this branch of the fine arts, at least, we must appear with very slight pretensions in the face of the world." In that opinion we concur, but it would be an imperfect expression of our own opinion if we did not add that it appears to us the duty of British architects to raise a protest against such a work being taken as the exponent of the architectural taste of this country. The Institute of British Architects might well express that protest on behalf of their professional brethren, if they cannot by their influence save us from its being carried into execution.

It is to be observed, that not only has there been no competition for the design of this building, but that the design chosen was kept secret until the contracts for executing it were entered into;—that the contracts assumed the form of a great gambling transaction, the contractors being paid not *quantum meruit* for the work done, but £200,000 in one event, and £300,000 in another event, depending on the profits of the Exhibition;—that it is considered expedient that the building should cost three or four times as much as the Exhibition building of 1851;—and generally, that with respect to various important particulars as to the history and parentage of this design, there is at present very little public knowledge, and agreat deal of public curiosity.

References to Plan.

A.	Nave.
BB.	West Transepts.
CC.	East ditto.
D D.	Octagonal Halls under Domes.
E E.	Carriage Department, with Picture Galleries over.
F F.	Principal Entrances under Domes.
G.	Principal Entrance in Cromwell-road.
H H.	Side Entrances under Towers.
I.	Refreshment Department.
K.	Machinery ditto.
LLL.	Staircases to Galleries.
M.	Horticultural Society's Grounds.

In consequence of some details of the east and west fronts of the building being yet undetermined, we have given in the accompanying illustration only the south elevation in the Cromwell-road, which it is believed will not undergo any material alteration, and a general plan; with respect to which latter we must remark however that some slight modification in the position of the columns is contemplated, although not yet definitely settled. The front of the building in the Cromwell-road will be 1150 feet in length. The upper story of this will form the picture-galleries, 35 feet in height, and lit from the roof. The basement beneath will be devoted to the exhibition of carriages and road vehicles of all kinds, and will be lit by the windows shown in our elevation. Parallel with the picture-galleries, 300 feet in their rear, will be the nave, 85 feet in width and 100 feet in height. The nave will be crossed at its extremities by two transepts, each 700 feet in length, of the same width and height as the nave. At the points of their intersection with the nave there will be two polygonal or octagonal halls, 135 feet in diameter, each surmounted by a glass dome 200 feet in height internally, and 250 feet externally, measuring to the top of the pinnacle. The floors of these dome-covered halls will be raised somewhat above the floors of the rest of the naves and transepts, and will consequently command excellent views of both the nave and transept. The roof of the naves and transepts will be of wood, painted on the inside, externally covered with felt, and spanned by arched wooden girders. Just below the springing of the roof of the nave and transepts will be a clerestory, 25 feet high, sufficient, it is expected, in combination with the two domes and the side windows, to supply ample light to the entire building. Galleries are to be carried round the nave, supported on double rows of columns, 22 feet in height. In the centre of each of the octagonal halls will be a fountain surrounded by shrubs. The annex for the machinery department will be detached from the main building, and will run along the side of the Prince Albert-road. It will be 800 feet long by 50 wide, and about 45 feet high, and lit by a clerestory. The allotment of the area to works of art and manufacture, &c. of various countries, not having yet been decided upon, we are unable to indicate.

◆

THE SUEZ CANAL.

From the Journal of M. de Lesseps we learn, that up to the 23rd of February last the work was progressing vigorously. At Port Saïd the fourteenth railway had been laid down; the embankments were advancing; fifteen new rafts had been constructed, eleven of which had been sent on to the line of Lake Menzaleh, to aid in the opening of the canal to Kautara; the four others are used at Port-Saïd for the landing of goods coming by the lake, as the water was then too shallow to permit of the use of the ordinary boats. At the Seuil d'Elguise a quantity of machinery is being erected, and villages are being constructed for the labourers: it is mentioned as evidence of the extent of the works that 14,000 wheelbarrows are in use at that place. Eight dredging machines are at work on the lake, to establish communication between the northern extremity of the Seuil, or entrance, and the lake Menzaleh, now connected with the Mediterranean. The execution of the piercement, says the Journal in question, of the Seuil d'Elguise will solve the question raised by certain persons. The day that the communication between the Mediterranean and the Lake Tismah shall have been established, the possibility of the whole project will have been proved, for the other portions have been already executed, under one name or other, at four different times.

◆

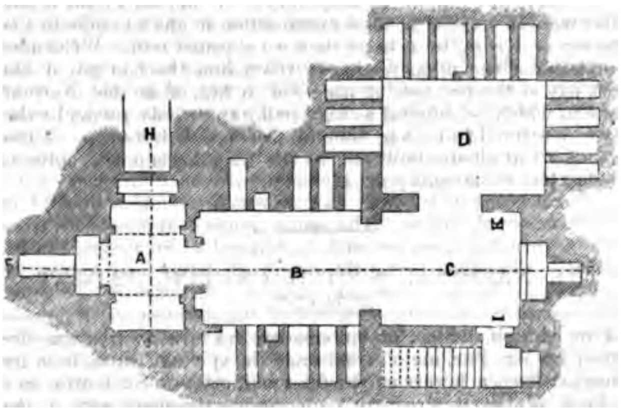
THE CATACOMBS AT ALEXANDRIA.*

By Prof. Donaldson.

In the illustrations accompanying the 'Architectural Dictionary,' now in course of publication, are some plans and sections of tombs in the catacombs about three or four miles out of Alexandria to the westward. They are very curious, presenting features of the Greek period, and are of considerable extent. Of late years Mr. Rous, chief engineer of the railroad, has had to cut away a portion of the rock in the immediate vicinity of the station, in order to gain further space for the accommodation of the increased traffic. These operations have brought to light a vast number of catacombs which were not known to exist. The upper surface varies from 20 to 60 feet, I think, above the present level, and the sides present a perfect honeycomb of tombs one above the other, excavated in the living rock. Each family catacomb consisted of one, two, three, or even four chambers, and had a distinct access from above, with its separate stairs cut in the rock, leading down to the subterranean vaults. Each chamber had two or three tiers of columbaria 2 ft. 3 in. to 2 ft. 10 in. wide, and 2 ft. 10 in. high, and from 5 feet to 6 ft. 6 in. deep. In some cases, as though for children, they are only 1 foot, 2 feet, and 3 feet deep. The ceilings were cut in the form of a low arched vault, and were painted a blue colour, having a flat oval moulding at the springing, also painted red.

In the tomb shown in the accompanying plan and sections, A, the principal sepulchral chamber, is 14 ft. 8 in. by 8 ft. 6 in.; having, on the side opposite the door, an arch flanked by antæ, and a sunk receptacle for the body cut in the rock; the lid, if any once existed, is not now remaining there, though others have been found. Over this was cut, at right angles in the rock, a columbarium to receive a body, 2 ft. 4 in. wide, by 2 ft. 8 in. high, and 6 ft. 9 in. deep. At one end of this chamber there was a like arrangement without the columbarium over, and part of the back being partially broken away, and a portion of the wall in another part of this chamber, which we found to be only 6 or 9 inches thick. Those apertures disclosed on the other side of thin walls other sepulchral chambers belonging to distinct tombs of other families. The antæ had beams over them sunk into the rock, dividing the ceiling into three compartments. The doorway leading into this chamber had on the outside three-quarter detached columns, over which was an entablature and pediment. There were considerable remains of colour, and paintings of flat Egyptian figures in panels, showing that, although the architectural features were Græco-Roman, the pictorial decoration retained the character of Egyptian art.

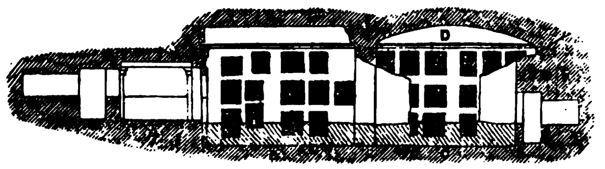
Fig. 1.



Plan.

The level of the principal chamber A is about 2 or 3 feet above the floor of the next B, which is 18 ft. 11 in. long by 13 feet wide, also vaulted. The two sides only of the latter chamber are pierced for columbaria, three ranges high, five or six of a row irregularly placed. The chancel C forms a species of vestibule, 16 ft. 9 in. by 13 ft. 8 in., having its sarcophagus cut in the rock, and columbarium over at the back of the recess.

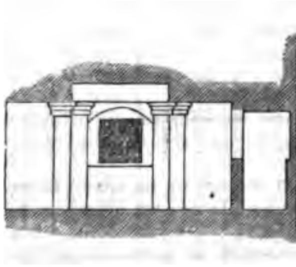
Fig. 2.



Section on Line E F on Plan.

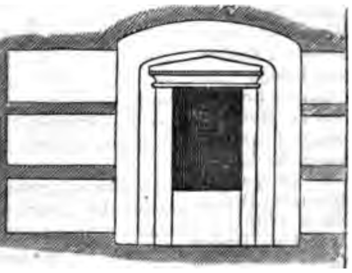
An aperture, 8 ft. 3 in. wide, led into a sepulchral chamber D, which had three tiers of columbaria on the three sides, there being six in each tier on the side opposite the entrance, and space for four in a row at each end; although at present only three were cut, leaving room for future bodies to be received. Each of the openings in this chamber has narrow, delicate architrave mouldings of a Pompeian character, worked in plaster, with thin consoles to support the head mouldings. I found this to be the case in other tombs. From the accumulation of *débris*, and collection of water, it was impossible to ascertain precisely the heights of the chambers; but they must be about 11 ft. 3 in. to the springing of the vault, and the vault itself rises 2 ft. 6 in., giving a total height of about 13 ft. 9 in.

Fig. 3.



Section on Line G H.

Fig. 4.



Section on Line I K.

While at Alexandria, Prof. Donaldson visited Pompey's Pillar; and on examining the base he was surprised to find that a number of boulders were placed irregularly under it. He was enabled to push a 5-feet rod through the fissures; and upon further examination found an opening large enough to admit his body. On entering it he ascertained, greatly to his astonishment, that the pillar rested upon a square block of stone, in the centre, of smaller diameter than the base of the monument itself. The pillar stood upon a mound, 100 feet above the level of the surrounding country. He had asked Mr. Rous, the engineer to the railway, to examine it thoroughly, in the hope that, if the pillar were in danger, some representation might be made to the Viceroy of Egypt, to take steps for its preservation. The circumstance of the pillar resting in the manner he had stated was most extraordinary; and it occurred to him that the block of stone to which he referred as supporting the whole, might be the upper portion of another column or obelisk imbedded in the ground. But whatever might be the hypothesis on the subject, the fact itself was most curious.

---

* Read at the Royal Institute of British Architects.

◆

THE NATIONAL SCOTCH CHURCH, REGENT SQUARE.

This church, which, as our readers may be aware, was designed by Mr. Tite, and erected some thirty years' since, is in its principal front a highly successful modification of the west end of York Minster—of course omitting the greater part of the decoration with which that noted façade is so profusely embellished. It was recently resolved to restore and renovate the whole fabric, the interior of which was much decayed; and for this purpose the designs and suggestions of Mr. John Gibson, of Westminster, were adopted. The first step was to restore the principal front and towers, which unfortunately had been built of a friable magnesian limestone. In this process, new pinnacles, parapets, &c., were necessitated, after adding which the whole of the moulded and ornamental work, together with the entire plain surfaces, were saturated with Ransome's preservative solutions; the whole now presenting a fresh and crisp appearance. The roof has been entirely boarded, felted, and re-slated. The whole of the inconvenient seating and floors have been removed, the fronts of the galleries and the ceilings under them cleared away, and the building well nigh gutted to make way for the new works. Open benches of a good size, with sloping backs, have been substituted for the old pews, and the seating in the central area has been entirely re-arranged. The floors of the galleries have been considerably raised, and the ceilings below them heightened. The gallery fronts, which were previously executed in plaster, and quite plain in character, have been tastefully decorated with tracery panels throughout, crowned by an embattled capping, executed in a light material, patented some years ago by M. Desachy, and called "le staff." The acoustic properties of the building, which were of a very defective character, seem to have been nearly perfected by the various alterations.

At the rear of the church, a lecture-hall, 57 feet long by 22 ft. 6 in. wide, has been erected, having an open timber roof, and lighted between the principals; which latter spring from moulded stone corbels. The walls are divided into bays by chamfered piers. A room for the officials has been provided near the principal entrance; and the staircases, porch, and class-rooms, have been thoroughly repaired and restored.

The church, lecture-hall, and minister's room, are heated by a combination of hot air and water. The artificial lighting of the church is egected by two large 81-jet sun burners, fitted with patent valves, which may be instantaneously lighted by a conducting wire from a voltaic battery, the application of which is exceedingly simple, and has been carried out by the inventor and patentee, Mr. Hart, of Edinburgh. The gas arrangements were executed by Mr. Strode; and the ventilation is provided for by three of McKinnell's large zinc tube ventilators, two of which are fixed in connection with the sun burners, and fitted with valves for regulating the supply of fresh air. One of these peculiar ventilators has also been fixed in the lecture-hall. Messrs. Lawrance and Sons have executed the works in the interior of the church, and the lecture-hall; and Messrs. Patman and Fotheringham the restoration of the external masonry.

A NEW RULE FOR DETERMINING THE THICKNESS OF ABUTMENTS ON UNSOUND STRATA, FOR SEGMENTAL AND ELLIPTIC STONE ARCHES.

r = radius at crown $\sqrt[6]{\tfrac{1}{2}r^5}$ *or* $\sqrt[3]{r^2 \times \textit{depth of key}}$ *Depth of key* $= \tfrac{1}{3}\sqrt{\textit{diameter}}$.

Name of Bridge.	Span.		Versed sine.		Radius at crown.		Actual thickness of abutment.		Counterfort to or opening in abutment.	Calculated thickness of abutment $\sqrt[6]{\tfrac{1}{2}r^5}$		Form.	Engineer.
	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.		Ft.	in.		
London Bridge	130	0	24	6	175	0	73	0	...	66	0	Elliptic	Rennie.
Neuilly Bridge	128	0	32	0	150	0	53	0	...	58	0	Do.	Perronet.
Waterloo Bridge	120	0	32	0	112	6	40	0	...	45	7	Do.	Rennie.
Stoneleigh Bridge	92	0	13	0	88	0	51	0	14 ft. opening	37	2	Segmental	Rennie.
Jena Bridge	91	8	10	8	102	0	45	0	...	42	0	Do.	Lamande.
Fonahard Bridge	85	3	8	7	110	0	38	4	9½' counterfort	44	9	Do.	De Volgie.
Pont de Montlouis	80	5	23	1	77	9	35	0	...	33	6	Elliptic	
Bridge of Louis XVI.	75	9	6	4	117	0	51	3	...	47	1½	Segmental	Perronet.
Staines Bridge	74	0	9	3	78	0	46	0	12 ft. opening	33	7	Do.	Rennie.
Kelso Bridge	72	0	20	9	57	0	22	0	11' counterfort	25	10½	Elliptic	Rennie.
Hutcheson Bridge	65	0	8	9	65	0	24	0	16 ft. ditto	28	10	Segmental	R. Stephenson.
Glasgow Bridge	52	0	8	3	45	0	17	0	...	21	3	Do.	Telford.
Hyde Park Bridge	40	0	4	10	45	0	25	6	6 ft. opening	21	3	Do.	Rennie.
Bridge over the Esk	37	0	3	0	58	6	25	0	...	26	5	Do.	Rennie.
G. I. P. Railway Bridges	30	0	7	6	18	9	10	0	...	10	3	Do.	J. Berkley.
G. I. P. Railway Bridge	20	0	5	0	12	6	7	0	...	7	4	Do.	J. Berkley.
Brunoi Bridge...	19	2	2	7	19	2	10	2	...	10	5	Do.	Perronet.
G. I. P. Railway Bridge	10	0	2	6	6	3	4	6	...	4	1	Do.	J. Berkley.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—May I request the favour of your inserting in your Journal the following original rule for determining the thickness of abutments on unsound banks, for either segmental or elliptic arches of stone, as coinciding nearly with the practice of the best engineers. The following examples will show the agreement of the rule with the existing bridges, both segmental and elliptic.

I was preceded in the publication of the new rule for determining the depth of keystone, which I had found nearly a year ago, and written it down in my note-book. I was agreeably surprised to see the very same rule appearing in your Journal of December last; the only difference being that, instead of the formula [found by Mr. Trautwine, I had for superior dressed stonework [$\tfrac{1}{4}\sqrt{\text{diameter}}$], and for brick and rubble work [$\tfrac{1}{3}\sqrt{\text{diameter}}$], as my formulæ. The formula of Mr. Trautwine being the result of independent thinking, I had the satisfaction of finding that I had hit upon the same rule.—I am, &c.,

Jagannath Sadasewjee,
Assistant Engineer and Teacher, Engineer School,
Kurrachee.

Kurrachee, 7th February, 1861.

ON CONSISTENCY IN ARCHITECTURE.

Being the Second of a Course of Lectures delivered at the Royal Academy,

By Sydney Smirke, R.A.

Many years have passed since the desk at which I have now the honour to stand was occupied by Sir John Soane: I was then in my earliest pupilage, but I carefully noted his sayings, and made a record on paper of my recollections every evening. In one of those lectures I well remember his dwelling with great emphasis on this rule—namely, that it was not sufficient merely to adapt the interior of a building to its special purpose, but that its exterior character should also be conformable to the purpose for which it was erected; and the lecturer quoted the well-known maxim of Demosthenes, who taught that the first requirement of the orator was action; the second, action; and the third, action. This led the worthy professor to paraphrase the dictum of Demosthenes, and to say that the three great requirements in architectural design were "character, character, character!" Forty years have not effaced the recollection of this dictum, or impaired its force; it is indeed a truth with which I am far more impressed now than I was when it was uttered by my distinguished predecessor. "Be what you seem!" the moral teacher cries, and the lesson applies with equal force to the practice of our art. It would indeed seem to convey a truism which would scarcely need to be enforced, did we not find it so frequently overlooked in practice. A spendthrift builds himself a solemn abbey, in which, it is true, vigils are kept, but not the vigils of prayer and fasting. Poorhouses and reformatories are crenellated and loopholed with mediæval sternness, as if it were likely to be made an object of hostile attack; whilst red tape and foolscap are sold in a shop faithfully modelled after the type of a palace of the Pharaohs. With such examples then daily before our eyes, I feel myself justified in repeating that a consistent and appropriate character should never be lost sight of in architectural works. It is a quality the importance of which should be constantly impressed upon the mind of every student.

But not only does this maxim apply to the general exterior aspect of a building. All objects that enter into the composition of a piece of architecture have some particular character which seems especially to belong to them, and which it behoves us to pursue. However we may vary the treatment of them; however much we may overlay them with ornament, we should be careful to do nothing calculated either to disguise or conceal their special character. Their motive and rational principle should be apparent and unimpeached; and honesty and good taste alike demand that in the treatment of their details we should seek rather to display their purpose than to conceal it. Thus, a column is a vertical support, and in designing a column its fitness as such should never for a moment be forgotten. Yet there is nothing perhaps which exhibits the waywardness of art more than the column. Its purpose is simple and obvious; its duty is as apparent as it is possible for any architectural feature to be; and yet it would seem that architectural ingenuity has been racked and tormented to devise modes of departure from that simple type which its mechanical duty seems to render so obvious. The Hindoo builder rests his weights upon fanciful and extraordinary compositions of animal and vegetable life. A similar barbarity was prevalent in Italy in the early mediæval period, when we see the shafts of columns poised most inconveniently upon the backs of monstrous animals.

But without dwelling on preposterous excesses of this nature, which are the natural results of a bold but uncultivated fancy, propriety has been defied in a great variety of ways, and at perhaps all periods and ages of art. To some of these it may be expedient that I should advert hereafter.

Probably the most perfectly unobjectionable realisation of the idea of a vertical support may be found in the Greek-Doric shaft, where the delicately-expressed flutings are in perfect harmony with the idea of an upright support, those vertical lines tending to fix the mind on the special purpose to which the shaft is applied, without scoring it so deeply as to suggest any idea of diminished strength. One of the principal charms of the clustered shaft which characterises Gothic art at its best period consists, I apprehend, in the strongly defined vertical lines so exactly harmonising with the known purpose of the shaft, although it certainly cannot be said to convey the idea of strength so emphatically as the Greek pillar. The bands or horizontal interruptions occurring at intervals in the length of these slender shafts, do not materially disturb the idea of verticality, for they are too unobtrusive to do so; but if we greatly multiply these bands in number, or materally increase their bulk, the sentiment of the shaft is impaired, and the eye is at once offended by the seeming inutility and even discordance of such interrupting bands.

One of the earliest conceits introduced into Roman architecture in its decadence was the substitution of spiral for straight lines of fluting; a change manifestly injurious to the effect of the pillar, and leading the way to a variety of kindred barbarisms, for it is in the nature of all error to propagate itself in other and varied forms. The spiral flutes and beads suggested the twisting of whole shafts which are to be often found in early mediæval work, until at length the shaft altogether lost its character of a vertical support, and we find them coupled and intertwined and knotted, after a fashion more like ropes than cylindrical shafts of stone or marble.

Raffaelle, in designing his immortal fresco of the Beautiful porch of the Temple, incurred a grave responsibility in setting that example of spirally twisted shafts, to be too readily followed by those who knew not how to distinguish between the requirements of the painter and those of the architect. Had the composition been scored and cut up by the vertical lines of a number of ordinary columns, the effect would necessarily have been unseemly, and the painter was therefore tempted to give them undulating forms, which associated well enough with the accompanying figures. But it is worthy of note that this great master, when he worked as an architect, committed no such mistake as to give such unsubstantial forms to real stonework. On the contrary, the few buildings with which he enriched our art are remarkable, even at that early period, for purity of form and propriety of design.

How heavy are the responsibilities of those on whom great genius has been conferred! Michael Angelo, by the *capriccios* which he permitted himself to indulge in when he designed the tomb of the Medici, was little aware that he was paving the way to that monstrous progeny of broken pediments and other violations of propriety which often defaced the architecture of later schools. So his matchless contemporary, Raffaelle, by having traced on the walls of the Vatican those graceful contortions, so pleasing to the painter's eye, but so little adapted to execution in real stone and marble, may perhaps be regarded as the real parent of those fantastic masses of bronze and stone which are scarcely censured in the baldachino of St. Peter's, the porch of All Saints' Church at Oxford, and in a hundred other less distinguished localities.

Certainly commanding genius has its duties as well as its privileges: its faults become consecrated by their association with so much acknowledged merit, and an error is dangerously seductive when it comes recommended to us by the sanction of a great name.

I should be dwelling too long on this subject of the column—important as that subject certainly is—were I to do more than shortly advert to the curious and fantastic forms with which it has at various times and in various countries delighted artists to impart to that feature. At Liege we have it whimsically assuming the likeness of a gigantic baluster, an idea to which the Quatrocentists of Italy had been also led by the loose rein which they were wont to give to their masonic fancies. At the Pavian Certosa we shall sometimes find their shafts divided into two distinct parts; the lower part straight and normal; the upper part degenerating into shapes fitted rather for confectionery than masonry. Ivary, an architect of some merit, and greatly employed in the north of Italy during the seventeenth century, exaggerating the faults of the Quatrocentists, devised columns of which the upper part is twisted, like those of his predecessors, whilst the lower part is bulged out into the resemblance of a baluster. These curious inventions may be compared to the variations on a simple air in music; sometimes so erratic that you can hardly trace the parent melody; sometimes retaining much of the air, but so overlaying it with extrinsic additions and decorations as to deprive it of all its original simplicity, and even identity.

Perhaps one of the most attractive variations is that where the shaft is enriched by superficial foliage, some ivy or vine seeming to clasp the pillar, and to twine its tendrils round the ponderous cylinders. Many such cases occur in the buildings of the Quatrocento period; and there is no denying their beauty, though we may question their architectural propriety. During the Mediæval period these sculpturesque shafts may often be met with, as at Melrose Abbey, but in greater beauty and variety in Italy. These varieties may all perhaps be regarded as the natural offspring of the beautiful stems of candelabra which abound in Classic art, and where the most exquisite delicacy of foliage was often indulged in without restraint, and of course without violation of any architectural propriety. To the period of Renascent art, that period so original, and so fertile, at least in its earlier phases, in quaint and picturesque devices, we may attribute the introduction of another curious irregularity in columnar architecture—namely, the building up of shafts in what are called rusticated blocks, sometimes alternately cylindrical and square, sometimes vermiculated, sometimes roughly hewn as from the quarry, sometimes in alternate bands elaborately carved in an endless variety of ways.

The love of simplicity and dignified good sense which marked the earlier phases of Classic art are nowhere more conspicuous than in the design of the Greek column: no trace of this anomalous treatment to which I have been adverting occurs even in the later period of Classic art. A shaft, when not actually monolithic, which was always an object much sought after and highly prized, was carefully constructed so as to convey an idea of unity, and to bespeak its singleness of purpose—that of vertical support. But when the original purity of design gave way to a love of novelty, builders thought of dividing the shafts into a multiplicity of parts, marking the horizontal bed-joints by deep channelling, all tending to convey the idea of a number of small stones piled up on each other, in lieu of the primitive idea of a unit or monolith. It is to this departure from the first intention, and forgetfulness of the original object of any architectural feature, that may be traced most of the errors for which our art is often so deservedly condemned.

Before quitting the subject of columns it is incumbent on me to take this occasion to express my unqualified condemnation of the practice, however common, of converting a single insulated column into a monument. Neither the undoubted Classical origin of this form of monument, nor the graceful proportion of the column itself, can be regarded as any justification of this manifest misapplication and perversion of a great architectural feature. Even our silversmiths have ceased to make Corinthian candlesticks, although the solecism still lingers among some competitive candidates for monumental street architecture. By how much we may admire the true adaptation of a column in form and proportion to its purpose of supporting a vertical pressure, by so much are we bound to condemn it when we find it standing idle and useless, or with no duty but that of lifting up to a dangerous eminence, and beyond the reach of distinct vision, some vase or other insignificant object, or some statue of a bulk and weight utterly disproportioned to the shaft of so colossal a pedestal. The very form of the capital at once betrays the impropriety of this application of a column. Whatever the style of art, whether Egyptian, Greek, Roman, Byzantine, or Gothic, the capital invariably spreads itself out to receive a burden pressing on it perpendicularly; the abacus in some shape is expressly adapted for the reception of that burden, and when the burden is not there, the abacus becomes unmeaning and superfluous. We must not do the injustice to early Classic art of supposing that we have any evidence of such a misappropriation of a column in the best times. The idea of setting up a monumental column seems first to have occurred to the degenerate sons of Roman art, an art which invented little, and seldom borrowed without some disfigurement or deterioration. It may indeed be presumed that the practice of erecting this fragmentary portion of a portico may have been justifiable in its origin on the ground of its being a trophy—the material evidence of the ruin of some hostile city; if so, however, no such apology can be offered for the colossal pillars erected by the emperors.

The obelisk, of much earlier times, and of more Asiatic character, was in every respect more consistent with reason, and therefore with good taste. By narrowing upwards from a broad base it conveys the idea of stability, and the simplicity of its form, whilst it seems to secure to it an enduring existence, is in itself one of the causes of its grandeur. Nor is such a form liable to the imputation of having been, like the column, an object transferred out of its proper place to act an unsuitable part. It is true that, in adopting the obelisk as a monument, we are perhaps not applying it strictly to its original primitive purpose. The Egyptians, it is said, figuratively designated them "the fingers of the sun," for they were originally erected as the gnomons of colossal dials; the shadow from the lofty shaft pointing to the hours ranged in a gigantic circle upon the surrounding area. The obelisk however ultimately ceased to be applied to this utilitarian purpose, and (I know not when) became, like the Celtic monolith, a simple monument, for which purpose it seems, as I have said, admirably adapted.

With this example of fitness and propriety before us, let us not resort to this erroneous use of the column. We have already had a satiety of triumphal columns; there is scarcely a large town that does not own some specimen of this deplorable misapplication, to which the public taste is only reconciled by the frequency and familiarity of the vicious practice.

We will now turn to another instance of that aberration of taste which so easily misleads by tempting men to forget the real use and purpose of an architectural feature. The abrupt vertical termination of the sloping sides of a roof forms the pediment or gable. The shape is the result of a necessity: its origin is simple and manifest, and stands in no need either of concealment or of qualification; yet there are perhaps few features in the use of which architects have so often testified a perverted taste, or have deviated so widely from good sense. As usual, the earliest forms of pediment are the most honest, and therefore the most pleasing. With that simplicity of character which distinguished Greek art, the early temple presented the gable ends of its roof without the slightest disguise, the pediment simply representing—or rather I should say, actually being—a cross-section of the roof. The same obvious sense of propriety and fitness led the Greek architect to occupy the blank triangular space or tympanum with sculpture, at once rendering the undisguised end of his roof a source of beauty, and by the nature of his sculpture giving to it an intrinsic moral value.

As art travelled westward and northward, the original purpose of the pediment was still not disregarded, and no material change was effected by the Romans, beyond giving the acclivity of the sides of the pediment somewhat greater steepness; and this was no caprice, and in no respect a departure from the primitive object of the form, for the change of climate reasonably led to this change in the angle of the pediment. The decay however of Roman art is marked by the invention of the curved pediment, applied at first probably only over small openings, but afterwards more boldly adopted as a substitute for the original and natural gable end. It was at this period of the decline of art that we find, as at Diocletian's palace on the north coast of the Adriatic, and in the splendid though barbarous architecture of Baalbec, the example set of broken pediments, a grievous departure from simplicity, which found too ready an acceptance in far later times. Nevertheless, in the succeeding period we still find but little inclination to abandon the ordinary form of pediments, of which so many noble examples of better times were then still remaining, especially on the classic soil of Italy. The dates assigned to buildings of this dark age of our art are not safely to be relied on, but certainly the church of St. Ambrogio at Milan, and of the Duomo at Murano, near Venice, are very early Christian works; and we there find the antique Roman pediment almost in its pure form and legitimate application as the abrupt termination of an ordinary roof.

It was at a somewhat later time, at the commencement of the so-called Mediæval period, that a singular practice arose, especially in the north of Italy, of breaking up these pediments or gables, and disturbing their original simplicity, by excavating, as it were, the surface of the tympanum with a crowd of shallow, inaccessible, and entirely superfluous arcades. But the original type of the Classic pediment was afterwards still more completely obliterated by the general suppression of the horizontal cornice, or base line of the pediment. The increasing steepness of the pitch at the same time caused a further departure from the old type, due no doubt to the gradual extension of art towards the North.

It was thus that by progressive steps the Gothic gable arose, on which the carver's and the sculptor's beauties were lavished with so free a hand, that it became one of the distinctive glories of Mediæval architecture. Charmed by the graceful and aspiring form of this novel feature in our art, a passion for its use arose among church builders, which, as usual, led to excess, and to an indiscriminate application of it. Lofty gables arose, which, regardless of their original purpose, had in truth no roof whatever behind them—sometimes indeed with windows immediately behind them; and they were carved, and traceried, and perforated, until they became the mere anatomies of gables,—favourite themes as it were, whereon the mason might disport and exercise his fanciful and inventive genius, utterly setting at naught the fine-spun theories of those martinets in art who would insist on every form in architecture being applied to some special useful purpose; a view which, from Vitruvius down to Pugin, teachers have urged on us far more diligently by their doctrine than by their practice.

I should observe that these *chefs-d'œuvre* of masonry are of Northern extraction, and occur rarely on the soil pre-occupied by the ancient Classic pediment. It is indeed curious to mark the pertinacity with which Mediæval artists, when working on Classic ground, adhered to the old style, or sought to amalgamate it with their own. The frescoes of even the thirteenth and fourteenth centuries are full of illustrations of this lingering semi-Classic feeling; nor are examples wanting of it in the buildings executed at that early period. Many examples might readily be cited, but I will name but one—namely, the archiepiscopal throne in the church at Assissi, which bears every mark of being of the date of the earliest portion of that building.

The Mediæval gable in more northern climates appears to have reached a sort of climax of intricacy and decoration, when its very existence became threatened by the remarkable change in all the arts of design at the period of the revival of Classic forms. Most of the features of Classical architecture were then in some modified form or other re-introduced, and among them the pediment. But the cold formality of the ancient gable was scarcely consistent with the exuberant genius of the Quatrocentists; accordingly we find semicircular pediments became greatly in vogue among them, and were the source of much beauty and novelty, although irreconcilable with a strict adherence to reason, and to that fitness to its purpose which reason must ever suggest to us, and which seems to offer the best if not the only safe standard for the guidance of our judgment in matters of art.

The Classic pediment and the Gothic gable were, not only apparently, but in strict reality (as we have already seen) the wall which terminated and closed up the extremity of the roof; but at the stage to which architecture had reached at the time to which I am now adverting this gable became rather an ornamental wall built up for the roof to abut against in the best way it could, and therefore it was not thought necessary to make it conformable with the slope of the roof. The circular gables of the Chiesa di St. Rocco, and many other buildings which I might name, are picturesque vagaries, and admirable perhaps for the variety they introduce into the composition, and as liberating architectural design from the rigidity of straight lines and sharp angles; but they must be admitted to be unjustifiable on any principle of sound criticism. Had they been in truth vertical sections of domes there could have been nothing to say against them; but as representing the end of any ordinary pitched roof they are false and unmeaning. Much therefore as I admire and respect the art of the Quatrocentists,—much as I would wish to see its numerous beauties recognised and its graceful inventions studied, I should be indeed sorry if the striving after new and unwonted forms and fanciful compositions, which is but too apparent in the present day, should lead to the reproduction of so great an anomaly as the circular pediment.

The more careful study of ancient architecture soon led the Quatrocentists to abandon this form of pediment, except in small interior compositions, such as altar-pieces and tombs, and in the subordinate parts of architecture, as the dressings of doors and windows; and the more accomplished architects brought their pediments generally down to the normal type. I do not call to mind any examples of these picturesque anomalies having been executed by Bramante, certainly none by his nobler pupil Raffaelle.

But now a new danger threatened the integrity of the pediment. In an unfortunate hour it occurred to some artists to break the continuity of the sloping sides of the pediment; and, perhaps with a morbid anxiety to relax the severity of the angular pediment, they contrived that solecism in art which I have taken more than one occasion to point to with reprehension—namely, the truncated or broken pediment. Some early indications of this error occur before the sixteenth century, but to the best of my belief only in the works of fresco painters. I am aware of no realisation of the scroll-shaped pediment before the sixteenth century. It is however to no less an authority than Michael Angelo (as I have already noticed in the present lecture) that we owe, if not the first practical execution of the broken pediment, at all events the questionable honour of having been the means of bringing into favour that great architectural anomaly. It is certainly to his great example that we are indebted for a numerous progeny of most grotesque and absurd pediments; one of those departures from good sense which bring opprobrium on the architecture of the sixteenth century.

The near relationship that architecture and sculpture bear to each other is undeniable. The mutual assistance that those arts are able to lend to each other, the similarity in many respects of the objects pursued by the two arts, would seem to render the cultivation of them by the same individual, if not essential to excellence, at all events a powerful auxiliary in establishing the character of a great artist: yet, "so vast is art, so narrow human wit," that we can with difficulty point to any individual who has in himself united those arts with that equality of power and intelligence which are necessary in order to prevent the one art from overruling the other.

Taking, for the purposes of comparison, perhaps the two most prominent artists the world has produced—Phidias and Michael Angelo—we observe (so far at least as we know or have the means of judging of the former) that whilst in the works of Phidias the sculpture was doubtless made essential to the due effect of his architecture, it was nevertheless always subordinate to it, and was never permitted to override it; the leading architectural lines of his building, as the metopes, the friezes, and the tympanum, were in no case allowed to be interfered with by the sculpture, but retained invariably their undisturbed continuity and distinctness. Intimately intermixed as the sculpture was with the architecture, it kept its place as a mere decorative expletive—an ornament in fact. Full no doubt of significance, and pefectly appropriate in character both as to treatment and design, but still a non-essential ornament.

In the works of the other great genius whom I have named we find these conditions reversed. Although undeniably great in architecture and great in sculpture, I think that the common voice of his posterity proclaims him to have been far more a sculptor than an architect. In the very instance to which I have adverted, the Medici monument, the feeling of the sculptor obviously preponderated. It suited his composition to place his figures recumbent on the sloping sides of a pediment, and he therefore so placed them, omitting the intervening apex of the pediment: thus committing an architectural absurdity, while he produced, it is true, a picturesque arrangement of his sculpture,—which was all he seemed to have cared for. We may say however in his defence, that in the arrangement of sculptured groups of figures the modification of known architectural members may be regarded as a poetical rendering of them, so as to make them subservient to the exigencies of high art.

It would be by no means difficult greatly to multiply instances of a similar sculpturesque bias in the works of this great man. I will however adduce but one other. In the Chiesa degli Angeli, at Rome, erected by Michael Angelo upon the site, and partly upon the walls and with the materials, of an ancient imperial palace, great pictorial effect has been produced, but in singular defiance of propriety. A huge circular tablet is so laid over the face of a wall which he desired to relieve from undue heaviness, as to overlay and almost to conceal the architectural lines, conveying the idea of a distinct object suspended against the wall, while it was in fact built into it, and formed an integral part of the masonry of the church.

There can be no doubt, I think, in the mind of any unprejudiced critic, that the example set us by the great sculptor of antiquity, of making his sculpture strictly subordinate to the architecture, is the more consistent with good sense and sound judgment. However elaborately architecture may be decorated and enlivened by the genius of sculpture, all the leading and essential lines of the composition should be dictated by its structural requirements, and should at least appear to express its main constructive features. There should I think be no intimate blending together of the constructive and purely decorative features; let them perfectly harmonise and combine together to make a pleasing whole, but let their respective limits never be ambiguous.

In the best age of Mediæval art this rule will, I think, be found to have been rarely departed from. It was in proportion as it degenerated that this principle ceased to have been acted upon, and sculpturesque excesses so came to be committed. The carver overruled the mason, until there arose those wonderful petrifactions as it were of architecture, which stood as if by a miracle, for their anatomy was concealed from view, and they appear rather to have grown than to have been built up,—the creation rather of vegetable life than of mechanical skill. I might refer as instances to the pendentive roofs of King's College Chapel and other similar structures, and to the singular productions of Kraft and others at Nuremberg.

In the age which followed the Mediæval period the best works fully illustrate the truth of the principle that would teach us to keep clearly defined, in due subordination and in a right relation to each other, the constructive and decorative arts. Great purity of design in this respect usually existed in the short but brilliant period of the early Renaissance. We shall seek in vain among the best works of that period for examples of the corrupt taste that would seem to abhor the simple outlines of that geometry on which the whole fabric of *our* art is founded. Although rich, occasionally even to a fault, in carved decoration, you will find those decorations ever kept within the limits of the frieze or panel or spandrel, or whatever other architectural compartment may have been left open for the ornamentist, after the requirements of the mason had been provided for. Thus their buildings preserved generally a great simplicity of outline and distinctness of form, although they may have presented a rich display of perhaps the most beautiful ornamentation that art has yet bequeathed to us. As however Renascent art advanced, it gradually departed from this wholesome rule, and the wider the departure the baser became the prevalent character of the art, until the improperly-called Classic style became disfigured by a multitude of gross errors. The most manifest structural requirements were often studiously concealed; the ordinary and characteristic features of architecture were lost amidst clouds and angels, floating by the aid of hidden cramps and ties; and a great deal of really ingenious construction was thrown away in simulating impossible construction.

The principle which I urge upon your attention may be illustrated by reference to what I believe to be a fundamental rule in the sculpture of the human figure, which forbids such a disposition of drapery as may wholly obscure, or even render doubtful, the actual position of the several limbs. In the work of a good master, however enveloped a figure may be in accessories, the imagination is never at a loss to determine its attitude or *posé*. So it should be with a building: its anatomy should be ever intelligible, however richly clothed it may be in embellishments. I dwell the more on this subject, because I think I am justified in expressing my fear that there is a strong tendency in the practice of the present day to overstep the limits to which ornament should be confined. Ornament is a most pleasing handmaid, but a very unreasonable and dangerous mistress.

There is another kindred error to which I think it may be profitable that I should advert. It is in some respects the converse of that which I have just reprobated, and consists of an attempt to give to mere ornament a false or affected utility. We sometimes may see a heavy weight of masonry—perhaps an integral part of a fabric—affecting to rest upon some manifestly insufficient basis, such as on foliage of the most delicate and fragile nature, or perhaps upon the edge of a shield obviously unfit to carry more than its own weight. This is an anomaly which no beauty of execution nor cleverness of treatment can justify. Painters may, no doubt, be readily permitted to represent bodies of very appreciable weight reposing on a mist,—Aurora may freely drive her wheeled chariot over the trackless clouds: for their paintings are but the embodiment of mere mental visions. These forms are but as words addressed to the mind's eye, while the architect has to deal with substantial realities. Whatever he does must be conformable, not only with plain reason, but static laws. The Pompeian decorator is quite at liberty to indulge his fancy in strange impossibilities; his cupid may emerge from the calyx of a blossom, and may poise on the tip of his wing a column, or a whole temple if he will; it is but a painter's dream after all. But when an architect so forgets the proprieties of his art as to realise in stone these vagaries, and places, or seems to place, a material burden upon these utterly inadequate supports, he is guilty of a frivolity unworthy of the character of his art. It is not that we need altogether condemn the use of these cupids and blossoms, but let them be superfluous adjuncts. Let the duty of a corbel or a capital be performed by a stone visibly shaped to its purpose and adequate to its task, and then overlay it as you will; the reins may then be given to invention to clothe that stone with whatever natural beauties the good taste of the sculptor may suggest to him as suitable and agreeable. In like manner, when we see the smoke of some laundry chimney issuing from among the leaves of some fictitious plant, however beautifully natural the leaves may appear, we repudiate the conceit as a gross breach of good taste in the artist who so misapplied the resources of his art.

But I have wandered widely from my theme: the real practical importance of the principle which I urge upon you must be my apology.

I was adverting with regret to the anomaly of the broken pediment; an error which struck deep root, and was the parent stock of an unaccountable variety of censurable forms. Strange it is that art is so prone to submit to the influence of fancy or caprice, as if the eye was ever craving for new forms. The simple, sensible, and strictly unobjectionable pediment thus became debased into a useless and ridiculous excrescence, under the impulse of tendencies which seem to be inherent in our nature. A like tendency betrays itself in a variety of ways; in nothing perhaps more visibly and viciously than in costume. Thus buttons are placed where they cannot possibly be applied to any useful purpose, justified alone by long usage and by the consequent prejudices of the eye; and thus shapes will long outlive the uses which had dictated them. So it is that architects are occasionally found erecting an array of buttresses, not because there is any lateral thrust to meet, but because they constitute a customary feature of a certain style.

Having dwelt long on the errors into which we are liable to be seduced by a disregard of the legitimate purposes of those two important component parts of architectural composition, the column and the pediment, it remains for me to point out to you with reprobation another and still grosser error, in the misapplication of the entire portico.

The unanimity is somewhat remarkable with which all critics, of every school and age, have agreed to admire the Greek portico, as comprising all the highest qualities of art in their purest and most complete form; and the great beauty of this model of symmetrical composition is enhanced by a sense of its obvious utility as a place of external shelter. For many centuries exclusively the distinguishing feature of temples, the portico was seldom permitted to be used in domestic architecture until the date of Augustus. From that period downwards it has never ceased to be applied to any and every species of structure needed by man, and, it must be admitted, often without the slightest appearance of necessity or utility.

The same critical remarks which I have already made in respect to the erection of a column as an ornament or as a mere pedestal, and not as a support (which is essentially and exclusively its special duty), are also applicable to the columnar portico, in all cases where neither shade nor shelter is of any appreciable value. To erect a portico in a position obviously inaccessible is an idle squandering of masonry with which the architects of the best days of Classic art cannot be charged.

A blind and unreasoning habit of repeating forms, without due regard to their purpose, has been among the worst faults of modern art. To build a gable, or a portico and pediment, without any roof behind to justfy or call for its use, or beneath whose shelter no man can betake himself, is an act which no reasoning critic, whatever be his admiration of the portico itself, ought to sanction. Like the small arcades which we so often see covering the apses of early Romanesque and Mediæval churches, yet often perfectly inaccessible and convertible to no possible use, we can only attempt their justification on the ground of picturesqueness or beauty, or because they serve to cloak a blank wall, or because they produce a pleasing *chiaroscuro*. It may be that there are occasions when these are sufficient and satisfactory reasons: the architect very imperfectly fulfils his mission if he does not gratify the eye whilst satisfying the graver requirements of his art. All that I would insist upon is that the more prominent and conspicuous features of a design should not be mere unserviceable appendages.

With regard to the use of colonnades partially built into a wall, as we see exemplified in the Banqueting-hall at Whitehall; it is not uncommon for architectural critics to condemn the practice as a departure from the dignity and real use of columns, and as something false or absurd. I am not however disposed to coincide in this view, and I can see no valid reason for condemning those engaged colonnades. Tested by the standard of common sense, I see no sufficient ground for such condemnation. Columns are points of support, and we may with equal correctness regard them in that light, whether insulated or engaged, for as supports they are equally valid in either case. We may regard the wall intervening between engaged columns as the means of inclosure, not of support,—assisting the columns, it may be, in the support of the entablature, but not an essential and integral part of the fabric. The great Doric temple at Agrigentum, and the Erecthæum at Athens, suffice to show that even in the best period of Greek art this practice was not held to be opposed to the canons of good taste.

The critics who would condemn engaged columns have, of course, a wide field for the exercise of their censorship in the engaged pillars or wall-shafts of Mediæval art, the use of which is an exactly analogous practice, inasmuch as they represent the points of support of the arches and vaulting which spring from the capitals. The truth is that there is perfect masonic propriety, whether in the wall-shafts of a cathedral or in the engaged pillars of a Greek temple. They represent an accumulation of power at the particular point of the wall on which the principal weight is charged; and not only have they constructive truth to justify them, but also great æsthetic value. These vertical lines of support convey to the mind the idea of the active and efficient support of any particular imposed weight, far more satisfactorily than can be effected by presenting a plain unbroken wall of apparently uniform solidity and strength; and this idea is still more forcibly and distinctly produced on the mind when the vertical engaged shafts are of different colour and material from that of the general surface of the wall. This practice, so prevalent both in Mediæval and Classic art, gave rise to additional beauty and variety by the use of coloured and polished marbles. Although I have justified and defended these engaged columns as true and legitimate architecture, I am nevertheless by no means inclined to encourage the gratuitous or too frequent use of them. There can be no doubt whatever that, in lightness and elegance of effect, advanced and insulated pillars, telling out distinctly and brightly against the lower tone of the recessed wall behind them, produce by far the most artistic and pleasing effect.

The object with which I set out in making these observations was to press upon your attention what I conceive to be one of the most important principles of design—namely, that every form in architecture should be, or at least appear to be, true to the purpose to which it is applied. The principle is of the widest application, and appears to me to be valid alike for the smallest objects of design and for those larger, more important features to which my observations have been more especially directed.

When Thucydides is deploring the moral deterioration of Greece, occasioned by the baneful influence of the civil wars on the manners of his countrymen, he says that a sort of duplicity had entered into the Greek mode of speech: false terms were introduced,—names of honour were applied to the base, and of baseness to the honourable; and he adduces this evil tendency as one of the most striking signs of the times. It is true that in uttering these lamentations Thucydides bears singular testimony to the general purity of Greek sentiment, when we find that the mere habit of misapplying terms of honour and of depreciation should be regarded by the historian as a national stigma, and as a serious public reproach: still, his remark has great significance, and may convey a useful lesson even to us as artists. The clear-sighted ancient historian and moralist could read the signs of the times in these unobtrusive and apparently insignificant indications: he saw that the habitual use of unfitting phrases and the untruthful application of words were evidences of an incipient national decay and deterioration. May we not draw like conclusions when we see an habitual neglect of truth in productions of art? And is it not a duty, becoming in all who are in a position to exercise any influence whatever on the mind of the young student, to strenuously endeavour to deter him from that downward course which leads to debasement of style, and with all possible earnestness to impress him with a sense of the beauty of truth?

Such certainly I conceive to be my duty here. Weak and faltering as my words may be, and though I may not be able to defend myself from the imputation of having set some bad examples, still I feel that I should betray the cause which it is at once my duty and my pride to advocate, were I not to use my best exertions to encourage the student in art to seek not only that which is ornamental or picturesque; not only that which affords a display of the most agreeable flow of lines, or is most attractive in composition; not only that which presents the richest groups of decorative features,—but to seek, above all things and before all things, that which is fitting in form and truthful in character.

INSTITUTION OF CIVIL ENGINEERS.

George P. Bidder, Esq., President, in the Chair.

Jan. 22.—The paper read was "*On the Rise and Fall of the River Wandle: its Springs, Tributaries, and Pollution.*" By Frederick Braithwaite, M. Inst. C. E.

This history was compiled from a survey of the river Wandle, made early in the spring of 1853, from its rise at Carshalton, and at Croydon —111 ft. 2 in. and 123 ft. 10 in. respectively above Trinity high-water mark—to its outfall in the Thames at Wandsworth. In the course of the survey, special notes were taken of the several springs, tributaries, and sewerage from drains which swelled the amount of the water. The levels of the successive falls of the river from its spring-heads, through the numerous mills, were carefully taken; also a complete set of gaugings of the water from the numerous springs and tributaries.

The branch of the river rising at Carshalton was said to be supplied from three principal springs—the Grotto Spring, the Hogs'-pit Pond, and the Ordnance Pond, which together yielded, when the gaugings were first taken, 13,246,020 gallons, and on a subsequent occasion 12,670,610 gallons, daily, or every twenty-four hours. The head of water at the lake in the grounds attached to the Ordnance School varied 4 or 5 inches, according to the rainfall. When the lake was emptied, it was refilled from the springs in thirty hours. This branch was also supplied from the Town Ponds and other springs. Five mills were situated on it, driven by wheels, having a united power of 71 H.P. The general character of the water was brilliant and pure, with the exception of that from the paper mills, and where the road drainage was discharged into the river after heavy rains. The water contained about 16° of hardness, and a small quantity of sulphate of lime.

The Croydon branch derived its principal flow of water from a stream called the Bourne Brook, which rose in Marden-park, about 8 miles south of Croydon. The supply from this source was however very precarious, as it did not flow more than once every five or seven years, when the rainfall was excessive, and then only lasted for a limited period; though it was in evidence that the Bourne did run for two entire years in 1841 and 1842, a period of great rain. Two other streams united with the Bourne about 2 miles south of Croydon, which, with springs rising in the Garden Pond and elsewhere at Croydon, brought up the total quantity to from 16,158,780 to 17,625,600 gallons daily. Other springs, issuing principally in the Lands Ponds, contributed 1,458,000 gallons every twenty-four hours; so that when all the streams had united to form the eastern branch of the Wandle (123 ft. 10 in. above T. H. W. M.) the river flowed at more than the rate of 19,000,000 gallons every twenty-four hours. The springs at Wadden Mill and from land drainage produced about 1,200,000 gallons, and the river was constantly increased from similar sources; so that when united with the Carshalton branch, at the oil and felt mills above Hack-bridge, the gaugings, which represented the entire flow of the Wandle in one stream, when first taken showed 63,488,520 gallons, and on the subsequent occasion 52,750,980 gallons, every twenty-four hours. The mills on this branch were four in number, but three only were in occupation at the time the survey was made, using water power equal to 25, 25, and 12 H.P. respectively. Above Hack-bridge the soil consisted of a mixture of chalk and gravel; but below the bridge it was wholly gravel or sand, though there was clay close underneath.

The paper then proceeded to notice the different mills situated on the main stream, giving a statement of their power, height above T.H.W.M., in many cases the quantity of water used at each, and other details. The operations carried on at some of these works, such as rinsing silk goods, washing skins, &c., and the chemicals employed, which when used were discharged into the river, tended materially to contaminate the stream. Indeed, it was generally remarked that the water below all the print works was much coloured when any print washing was going on. The colour did not appear to settle, it only became largely diffused. The water used for cleaning the blocks was also sent into the river. In clear weather the contrast between the water at the Carshalton springs and that at Merton-bridge was very marked; proving to the sight alone how unfit the water had become for drinking purposes, during its progress through so many works discharging impurities, and over such a soil, and receiving such drainage. In dry seasons this would be still more striking. There were twenty-five mills on the main stream, using 545 H.P.

Mention was also made of the amount of drainage water flowing into the Wandle from the surrounding land: one stream alone, on the eastern side of the river, at Mitcham-common, contributing 4,172,760 gallons daily. The Pickle, a dirty stream, joined the main river at Merton-bridge; and the Graveney, a considerable tributary, which had also a dirty appearance when the water in the Wandle itself was comparatively clear, entered the river at Mr. Payton's leather works. The average gaugings at Garratt's oil mills showed 83,469,060, 76,316,950, and 62,343,000 gallons every twenty-four hours. The gaugings of the river Graveney during the same period showed from 6,291,000 to 1,458,000 gallons daily. These quantities referred to a period when the river, its bed, and adjacent soil had been fully saturated with heavy rains, and afforded no criterion of the quantity due to dry seasons. The water in gravelly districts at such times was much wasted: then that stratum not only refused to part with it freely, but even deprived the river itself of water which flowed down from a district less influenced by evaporation. It might therefore be concluded that, in periods of drought, the true source of the supply to the Wandle would be found at Wadden and at Carshalton only; for the Bourne Brook became dry, and the Croydon springs were polluted. At present the supply from Wadden and Carshalton was found to amount to 32,941,800 gallons daily; but when the land-springs and other drainage waters were exhausted there only remained 18,367,920 gallons daily available for water supply, supposing the flow from the chalk to continue uniform. But when the river reached Wandsworth much of the water had been evaporated and filtered into the gravelly soil, and much had been filtered and carried away as sewerage, or been consumed in the works, so that probably not more than 10,000,000 gallons could be relied on, and that must necessarily be polluted.

In an appendix a table was given, showing the rainfall daily during the months of September, October, November, and December, 1852, over that portion of the district the nature of the soil of which was non-absorbent—viz. the tract of land drained by the river Graveney and the Collier brook, having an area of 4900 acres. The available water-shed area of the Wandle, in addition to this, amounted to 12,935 acres; and the length of the river from Croydon to Wandsworth was rather less than 9¼ miles. The entire details of the survey were also given in a tabular form.

Jan. 29, and Feb. 5 and 12.—Before proceeding with the regular business on the 12th of February, the president directed attention to the donations to the library which had been received during the present session; particularly noticing the handsome edition of the very detailed account of the 'Construction of the Great Victoria Bridge, in Canada,' from the author, Mr. James Hodges; the 'Report on the Ganges Canal Works,' in three volumes, with folio atlas of plates, from the Council of India, through the author, Colonel Sir Proby Cautley, K.C.B.; a useful German periodical, entitled 'Zeitschrift für Bauwesen,' from the commencement in 1851, from Mr. W: W. Collins, M. Inst. C.E.,—who had also presented a copy of Messrs. Tolhausen and Gardissal's 'Technological Dictionary in the English, French, and German languages;—and the 'Official Descriptive and Illustrated Catalogue,' with 'Reports by the Juries,' of the Exhibition of 1851, in six volumes, imperial 4to., from Mr. Andrew Cuthell, Assoc. Inst. C.E. The president, in proposing that the cordial thanks of the meeting be given to the several donors, expressed the hope that these excellent examples would not be lost upon the many new members and associates who had recently joined the Institution, and that it would be the constant aim of members of all classes to maintain the library in the highest possible efficiency.

The Discussion upon Mr. Braithwaite's paper, "*On the River Wandle; its Springs, Tributaries, and Pollution,*" occupied three evenings.

It was stated that the flow of water in the river Wandle was subject to extraordinary vicissitudes, such as were not usually met with in a stream issuing from the chalk. In 1858, when the river was gauged at Garrett's Mill, the quantity of water was as low as 11,200,000 gallons per day, whilst at the same place 92,000,000 gallons had been measured daily. Though short, this river was interesting mechanically as well as geologically: mechanically, as some of the best mills in England were built upon it, there being one by Smeaton, and another by Rennie; and geologically, because of the large volume of water drawn from the chalk hills in so short a distance. This was attributed to the upheaval of the chalk, and consequently of the London clay, between the rivers Wandle and Cray, so that it was impossible for any large amount of water to escape from the chalk between Croydon and Carshalton. The Bourne was dependent on excessive and long-continued rainfall; in fact, to the fall of water in a limited time being greater than the capability of absorption. When these conditions were reversed, then the Bourne ceased to flow. It was however contended, that there must either be some error in the gaugings at Hack-bridge, given in the paper as 63,488,520 and 52,750,980 gallons daily, or else that there had been exceptionally wet weather at the time they were taken; for as the drainage area only contained 56 square miles, there must be a depth of water equal to a permanent flow of 29 inches off the ground to produce 63,000,000 gallons every twenty-four hours. It was remarked that the circumstances affecting the river Wandle were of an exceptional character; for although the drainage area only consisted of a few thousand acres, yet at the back of that area there was a large tract of chalk country, from which no streams flowed, the water chiefly issuing in springs at a distance from where it fell. Some of these springs were intermittent, as was the case with the Bourne, not flowing more than once every five or seven years. The rainfall in the district varied from 16 to 33 inches, averaging 23 inches; whilst the amount of evaporation was more nearly a constant quantity, varying between 15 and 18 inches, and averaging 17 inches. The fluctuations in the river Wandle might therefore easily be accounted for; but the extremes of difference were incomparably less than in many other cases. To this it was replied, that the Bourne was not an intermittent spring, but was constantly flowing underground between the Godstone quarries and the Bourne culvert at Croydon. The origin of the spring might, it was said, be seen in the driest summer at those quarries. The flow from the quarries and from other sources into the culvert amounted to 500 gallons per minute. It was not until the quarries were about two-thirds full, and contained about fourteen or fifteen million gallons of water, that the water ran into Marden-park. Then the other outlets being insufficient for the discharge, it burst out at that place. There were three channels which it took:—first, from the quarries to Croydon. Secondly, a channel originating in the neighbourhood of the quarries, but only appearing above ground 4 miles lower down. It only began to issue out at this point in November last, and was now running at the rate of 1400 gallons per minute. The third stream commenced near Marden-park, on the road to Birch Wood. It began to run this month (February), and was now discharging 300 gallons per minute. Thus, so far from the Bourne rising in Marden-park, it was only when the first and second channels were overcharged that it flowed there. The combined waters from Marden-park and from the second channel were now running below Riddlesdown at the rate of 1500 gallons per minute; but the flow from the mouth of the Bourne culvert was 3500 gallons per minute.

It was contended that it was an unscientific mode of proceeding, to calculate the available supply of water for waterworks purposes by a system of averages. The minimum quantity was that which should be taken. The rainfall had been known to vary as 1 to 2, that was, from a minimum of 16 inches to a maximum of 32 inches per annum. Again, in one month in 1859, the evaporation exceeded the rainfall by 3 inches; whilst in the same month in 1860 the rainfall exceeded the evaporation by the same amount, making a difference of 6 inches. Further, the quantity that would soak into the ground was dependent upon the season and the previous state of the atmosphere—for if the ground was very dry, and the sun had much power, the rain would be nearly all re-evaporated—as well as upon the state of the weather at the time when the rain fell, the time in which it was falling, and the absorbent properties of the soil. In chalk districts too much generally was relied on. Out of a rainfall of 28 inches, not more than 5 or 6 inches penetrated by gravity, or sunk beyond the influence of summer heat. A distinction must also be drawn between a rocky precipitous district and a chalk formation consisting mainly of flat table land. Thus, on a hill of clay, or primitive rock, with a rainfall of 1 inch in ten or twelve hours, nearly the whole would run off. But on the steep chalk hills round London, rising to a height of 800 or 900 feet above the level of the sea, although there might be a rainfall of 2 inches in an hour, as sometimes happened, the whole of it would soak into the ground. There were large districts of an absorbent character round London and elsewhere, and on such drainage areas the whole of the water entered the ground immediately, especially during heavy rains. There was consequently very little flood water, the rivers were more equable, and the springs more continuous, than was the case with water flowing from other formations. On the red sandstone formation water was absorbed as fast as it touched the surface. In mountainous districts the minimum had been observed to be one sixteenth of the average flow, and the floods were sixteen times as great, the ratio between the minimum and maximum quantities being about 1 to 300. It was further remarked that, in this climate, the volume of water in streams and rivers had been known to vary from 1 to 500. In tropical or semi-tropical countries, there was a much wider margin; as a dry ravine might become a destructive torrent during rains and thunder storms. In the hill districts of Lancashire, Yorkshire, and Derbyshire, the springs amounted in dry weather to from a half to about three-quarters of a cubic foot per second, for every thousand acres of contributing ground, whilst the floods amounted to 200, 300, and even 400 cubic feet per second from the same drainage area. In the more impervious granite districts, and other primitive formations, there was almost a total absence of springs, and nearly the whole of the water went off in floods, the yield by springs in summer being trivial.

It was observed, that in a chalk country the volume of water in a stream was dependent upon the amount of percolation, though there might not be a direct ratio between the two. Streams were the result of the water draining out of natural subterranean reservoirs, formed by the rain which had percolated through the chalk, and which was held up by the impervious strata below. It did not follow that all quitted it in a single year; but it contained sufficient to furnish a certain outflow for four or five years, even if there was no rainfall. The inclination of the surface of the subterranean store of water was dependent not only on the amount of percolation, but also upon the nature of the chalk. In the middle chalk, north of London, the inclination of the water-line was at least 13 ft. 6 in. to the mile. In its lower beds, the chalk was of a nature to increase the friction, and it would be found that water stood at an inclination of about 19 ft. 6 in. to the mile at Berkhampstead, and as much as 40 feet to the mile in some parts of Kent, and elsewhere. The

"Bourne" which had been alluded to in the paper, and of which there was a similar case in Hertfordshire, might arise entirely from an excessive supply of water to the reservoir, when the inclination of the surface of the reservoir becoming greater, a stream would run on the surface where there was none before. A table of the rainfall and percolation through Dalton gauges, at Nash Mills, Herts, was then given. The gauge now used consisted of two cast-iron cylinders, each 18 inches diameter, turned to a knife edge at the top, and sunk to a depth of 3 feet below the level of the ground. One was filled with ordinary surface soil, and the other with fragmentary chalk, both being covered with grass and vegetation. Any rain that fell was absorbed by the earth within the cylinders, and whatever was not carried off by evaporation was collected in the bottom of the cylinders, and its amount ascertained in the ordinary manner. In this table the year was made to commence on the 1st of October and to terminate on the 30th of September; and the first six months were considered to be the winter half-year, and the last the summer half-year. It showed that by far the greater amount of percolation took place during the winter months, there being frequently none during the summer; and the average summer percolation through soil during twenty-five years was less than ¾ of an inch. The maximum winter rainfall was in 1852-3, 20·27 inches; and the maximum percolation in 1841-2, 17·98 inches. The minimum winter rainfall was in 1849-50, 8·58 inches, and the minimum percolation in 1858-59, 0·9 inch. The maximum summer rainfall was in 1860, 20·40 inches, and the minimum in 1843, 8·07 inches. Though the annual average rainfall of the last seven and the previous eighteen years was nearly the same, yet the proportions of the winter and the summer rainfall were 13·86 to 12·79 inches in one period, and 11·91 to 14·58 inches in the other; and the average winter percolation was reduced from 8·635 to 4·601 inches. There were many circumstances which affected percolation. If, for instance, ½ or ¾ of an inch of rain fell on one day, succeeded by three or four fine days, very little percolation took place even in winter. But should 2 inches of rain fall on two consecutive days, then, even in summer, water would find its way into the ground.

It was remarked that, of late years, the lower part of the river Wandle had been subject to great fluctuations, due it was believed, in some degree, to agricultural land drainage. Now, as soon as rain fell, it was more immediately discharged into the rivers and streams, the floods were more rapidly carried off, and were greatly augmented in wet weather, and the flow of rivers was diminished in dry seasons, so that there was frequently a great want of water. It was urged that there should be an economy of water during the winter, and the proper means of discharging it for purposes of utility in the summer. It was thought that underdrainage was sometimes carried to too great an extent, making the soil even dry and sterile. In the fen districts, if the water was drained below 2 ft. 6 in. or 3 feet from the surface, the crops were diminished in weight. On the other hand it was urged, that underdrainage might have the effect of permitting particular soils to absorb the rainfall quickly, and to give it out again in evaporation; and in these cases, underdrainage, so far from causing floods, would have the effect of preventing them. It was asserted that those who had paid the greatest attention to this subject considered deep agricultural drainage to be the most profitable; and that, so far from the drains acting as culverts to carry off all the water from the land, they served to economise it. It had been found necessary in stiff clays to place the drains at a depth of 4 feet, so as to keep that depth of ground warm and mellow for the nourishment of the crops. In porous ground, such as sand and gravel, the drains might be wider apart, and be carried to greater depth. The object should be, not to allow the water stratum to rise to the roots of the plants, and thereby keep them constantly cold. It had been said that underdrainage increased both the droughts and floods. The latter effect could scarcely be doubted; but droughts could only be increased by lessening the rainfall, which might probably result from diminishing the evaporation. It had been determined by experiment and by observation, although there were not wanting many contradictory facts, that by underdrainage evaporation was diminished rather than promoted. Thus, supposing the evaporation from water surface to be 33, the amount from saturated surface would be 30, and from drained surface about 20. The soil down to the depth of the drains had been found to be in a state of the most minute disintegration and comminution, thus creating those channels of attraction which would bring the water up from beneath the drains to the surface. Water only entered from the bottom of the drains. As the soil below the drains must first be replenished by the rainfall before they could run out, and as the water must pass the drain to replenish the subterranean depths, it was clear that the crust of 4 feet on the surface of drained land was unimportant in the consideration of this question.

As this discussion had an important bearing upon the past, present, and most certainly the future of almost every river in England, it was thought that the effect of urban drainage ought to be carefully considered, particularly in the case of small streams flowing from chalk districts. It was admitted that towns ought to be drained, cleansed, and be provided with all the conveniences demanded by the present state of civilisation; but it was contended that it was not necessary that the rivers should be fouled, there being several processes by which foul water might be prevented from running into streams. The Wandle was a notable instance of a river being polluted without cause. The sewerage of the town of Croydon was drained into it, and the sewage-water was said to be deodorised, but an insufficient quantity of disinfecting fluid was used to accomplish that object. It was afterwards turned over the land for the purpose of irrigation, and was subsequently allowed to run into a stream communicating with the main river. The result was that an abominable stench was produced. The works at Leicester, erected by Mr. Wicksteed, M. Inst. C.E., though not commercially remunerative, effected the purification of the water. The expense was not inordinate, as the experiment was made at a cost of £40,000, and at an annual outlay of £2500 a year, for a population of 70,000 inhabitants. There were two other modes of purifying town sewage-water, by pumping it over large areas from tanks—a system the cost of which was so great as to prevent its application—and by running it over land, and then it was worthless except as an irrigant, unless in combination with some cheap chemical agent. The reason why sewage-water could not be applied successfully to the irrigation of land, in the case of a large town, was that, as the sewage would have to travel a considerable distance, the fertilising matter became oxidised, and therefore valueless for agricultural purposes. With small towns such need not be the case, as the sewage might be applied fresh, before being decomposed; but then it would be a nuisance unless previously deodorised.

It was remarked that at Leicester, out of 13,000 houses, only 700 were connected with the sewers; and as the town was plentifully supplied with water, and the surface drainage of the streets was allowed to run into the sewers, it was not surprising that the sewage-water was tolerably clear. At Croydon, on the other hand, there was rarely a house without a water-closet, and in many cases two or three, all of which emptied into the sewers. But on the other hand, it was shown by the Report of the government chemists, Messrs. Hofmann and Witt, that the Leicester sewage matter was of the same average strength as the London sewage.

It was observed that, though the parish of Croydon had a population of 30,000, yet there were only 20,000 inhabitants in the town; and as regarded the locality inhabited by the other 10,000 persons, its watersheds were in other directions, and its drainage had nothing to do with the Wandle. When the Board of Health was established ten years ago, the river just below the town was foul with deposits of offensive mud on each side of the stream. Previously no effort had been made to keep the filth out of the river, nor was there any arrangement for purifying the sewage; and the river was, in fact, the general dust-bin, sink, and sewer of the town. Since then no expense had been spared to prevent the pollution of the Wandle; and it was believed that now there was no other inland town better drained, or where the sewage was disposed of with less inconvenience to the neighbourhood, than was the case at Croydon. The problem had been by no means an easy one. There was a population of 20,000 at the had of a river—at its very urn—with no other outfall or means of drainage but into the river. Now the sewage from 4000 houses was entirely intercepted. It was received into glazed-pipe sewers, was largely diluted with water, 200 gallons per house per day being used, and in one hour it was 2 miles from the town. The sewage was conducted through some fields, away from the river, till it came by gravitation to a farm of 96 acres belonging to the Board of Health. Here it was strained through gravel filters, to remove the coarse solid matter, about 20 tons of night soil being obtained per week. It was then, in warm weather, mixed with M'Dougall's fluid, as large a quantity being employed as was found by experience to be necessary or useful. At first 1 gallon of fluid was applied to 20,000 gallons of sewage-water, but as there was then a perceptible smell of tar at the outfall, the proportion had been reduced to 1 in 30,000. Subsequently the sewage-water was flowed over and through the grass and land of the farm. The result of sending the sewage over the grass land was, that the crops were largely increased, and the water flowed off pure and clear. There was no offensive smell, as the sewage was recent and much diluted, and it was only unwholesome in its effluvia when allowed to stagnate until putrefaction began. The sanitary condition of the town had also been greatly improved, and it was urged that the Croydon Board of Health should not be blamed or disparaged, when they had done and were doing all that was possible in the existing state of knowledge on this subject.

In reference to the value of "clear" water, it was mentioned that recently an inquiry had been made, whether an order of the Court of Chancery was being duly carried out in the case of Barnard *v.* Arkwright. The decision in that case had been, that no pernicious water from the cleansing of certain dog kennels, where some kind of arsenical preparation was employed, and from the larders appurtenant thereto, the dogs having been fed with the flesh of glandered horses, should be allowed to flow into the stream at Harlow. The defendant had constructed filter beds, and adopted a variety of contrivances in order to insure the water passing away "clear" and pure; and so it did to all appearance, but when bottled and allowed to remain for a day or two, it became perfectly pestiferous. This showed that the actual condition of water could only be ascertained by chemical analysis, and that mere appearances alone must not be be trusted.

In the course of inquiries relative to the pollution of rivers, it was found that Croydon proved the converse of the proposition, that the question of sewage irrigation was still far from solution. There was no relevancy whatever between sewage as it issued in a liquid state from sewers, and guano as it was in a solid state imported; nor yet between the sewage as it issued from the sewers, churned and pounded up and subjected to the action of the atmosphere and water, and the liquid manure found in tanks in farm-yards. The contents of the sewers being thus practically proved not to possess a fertilising character, it was considered whether by any known process they could be made to assume a commercial value. The processes hitherto tried might be divided into two classes, the "solid" and the "liquid." As a favourable illustration of the former, Leicester was cited, where the sewage was mixed with oily and fatty matters from the woolen manufactures and the wool combing. All the town required was, not profit, but that the river should be saved from pollution, by a system of deodorisation, and the separation of the solid from the liquid matters. In these respects the works had been successful. But the large quantity of *debris* obtained by the lime process could not be disposed of. In fact, a profit could not be realised by the manufacture of solid manures from sewage, as had been anticipated. The promoters of the Stanley-green Works having tried the "solid" process, and failed, resorted to the "liquid" process—to the application of liquid manure to market gardens in the vicinity. But the gardeners objected, and the demand not being equal to the supply, the works were closed. The Croydon sewage being poured on the land in a liquid state, proved to be a great nuisance, and when visited in 1858 there was a large accumulation of solid stuff. It was believed, according to the testimony of those best able to give an opinion on such matters, that these works had caused the very considerable disease which at one time visited Croydon. It had been laid down that malaria might be induced by open sewers and liquid manure passing through them; whilst it would be prevented by the liquid passing through pipes, and applied to the land by the hose. At the Watford Works, liquid manure was applied to the home farm of the Earl of Essex, near Cashiobury, under the most advantageous circumstances, but yet it was not commercially successful; the grass produced was of a rank character, and the works were a nuisance to the whole neighbourhood. At the Craigentenny Meadows, Edinburgh, the process of sewage irrigation had been in operation for sixty years. The sewage ran immediately upon what was waste land, and a large amount of grass was produced. It was contended that success was due in this case, first, from the fact of the land being of no intrinsic value; secondly, from its peculiar position; and thirdly, from its being possible to sell the produce—grass—to great advantage, owing to the proximity of the meadows to the city of Edinburgh, where milch cows, kept in stalls, were fed on the fresh cut produce. These meadows had been admitted to be a source of nuisance, and injurious to health, especially in hot weather, not alone to the immediate neighbourhood, but even to persons residing at a distance of 2 miles. As another illustration of the failure of open liquid sewage irrigation, the city of Milan was quoted. The sewage was there poured upon meadows in the vicinity of the city. According to Dr. Capelli's evidence, this had a decided influence on the health of the inhabitants, especially children, producing ague, neuralgia, rheumatism, and remittent fever. There was therefore every reason why capitalists should be deterred from embarking in sewage speculations, which, whilst they began in delusion, must inevitably end in failure.

It was contended, that the high value of the Craigentenny Meadows was due entirely to the effects of the sewage that was put upon them, and not to their proximity to the city of Edinburgh. It was stated that this land, previous to the application of the system of sewage irrigation, was bare sea sand, and at present it was merely covered with foul matter to the depth of an inch; that it was waste to use M‘Dougall's disinfecting fluid for nine months in the year; and that sewage might be put upon the land if it was fresh, and the land would disinfect it without any deodorising mixture. Putridity caused offensiveness; and putridity came with age.

A doubt having been expressed as to the correctness of an opinion given in the course of the discussion, relative to the failure of the Stanley-green Works, it was further stated that the undertaking was started by a company in 1846, when nearly £50,000 were expended, but no dividend was ever declared. Not more than 100 acres of land were watered at one time, nor was the system extended to more than 150 acres; and probably the company never received more than £500 for rent. A steam engine was erected at the Counter-street sewer, and from thence the sewage-water, which was neither strong nor of a fertilising character, was pumped upon the market gardens at Fulham-fields. Subsequently, the sewage coming along the Ranelagh sewer from Paddington was intercepted, and forced through pipes to Stanley-bridge. This matter was much richer, and the farmers did not object to it on that score. But the difficulties were endless; and it was thought that the idea of pumping sewage, and delivering it at a distance, after the manner of a water company, was perfectly impracticable.

In reply to the observations which had been made as to the operations of the Croydon Board of Health, it was stated that the intercepting sewers carried off a large quantity of water issuing from springs that would otherwise find its way into the river; that the vegetation at the farm was rotten, and, as a specimen of irrigation and application of sewage manure, it was, whether of sewage or clear water, the worst in existence; and that many of the sheep had rotted, showing that it was not a healthy piece of ground. It should be remembered that the Board only took the land into their own hands in consequence of getting into difficulties with the previous occupiers, some of whom took proceedings to recover damages on account of the application of this sewage manure. This method of application of sewage was not considered to be a proper one. It would be better that it should be simply treated, so as to prevent its becoming a nuisance. First, by straining, the solid matter (much of which consisted of decomposing animal fibrine or albumen, giving out a most odious stench) might be removed. If this was then mixed with quicklime, so as to be deodorised, it would make a good dry manure for the land. The next step was by precipitation, which might be easily effected with quicklime. By these means the water would be rendered clear and bright, although even then only one-fourth of the organic matter would have been removed. This alone would not suffice in comparatively small rivers; then an antiseptic must be provided, and there was believed to be none better than M‘Dougall's fluid in combination with quicklime. The water would thus be rendered perfectly innocuous. The idea of making the sewage matter of towns commercially useful should as a rule be altogether abandoned.

The laws relating to water flowing above ground were clear and well defined. They allowed a certain limited use and ownership, and any undue use or abstraction of such water could be immediately checked. Yet, by a recent decision of the House of Lords it was held that, provided the water flowing into a river by an underground course had not become visible or reached the surface, it might be abstracted even within a few yards of the river with impunity; so that, in fact, it was held to constitute an entirely different species of property. It was argued that the law ought to operate in the one case as in the other, and that the maxim of law should in both be carried out, "*Sic utere tuo ut alienum non lædas*"—so to use your property as not to injure another man's rights. To this it was replied, that the decision of the House of Lords in the case of Chasemore *v.* Richards (that was the Croydon Board of Health), was, that water under ground, like the air above ground, was unpropertied, and not the subject of any prescriptive rights. That whoever possessed the soil might sink a well, and pump to any extent, however much it might affect others, taking as large a quantity of water as he liked from beneath his own land; and if he dried or injured his neighbour's mill, mill-stream, or pond, that neighbour had no remedy against him, and must seek for water by sinking a deeper well or in other directions. It was contended that, in the majority of cases, no one could say positively that the water drawn by one person came from the land of another particular person—that in fact the course of underground water could not be pursued. All parties had therefore an equal right to it, and no other system of adjudication upon such rights could be devised than that which had been generally laid down by the judges. It was asserted on the one hand, but denied on the other, that the decisions in the cases of Chasemore *v.* Richards, and Broadbent *v.* Ramsbottom, had recently been disregarded in the case of Ennor *v.* Barwell; when it was held that underground water was the property of the person whose land it would reach by percolation and gravitation from a higher to a lower level. The discussion of the law of water rights was deprecated, as it was considered that it was a question with which the Institution was incompetent to deal, and could only be taken to the neglect of those matters which more properly belonged to civil engineers.

In replying to the remarks which had been made in the course of the discussion, it was stated that there were many circumstances to be taken into consideration with regard to the supply of water to rivers. Some were for the most part constant; others were fluctuating and variable. In any particular district the surface of the ground and the nature of the soil were constant, but the extent of moisture in the ground was variable. Again, some soils took up 90 per cent. of moisture, others not half that quantity. The rainfall was variable in amount, and in the time and manner in which it fell. The hygrometric condition of the air was likewise subject to many variations. Evaporation was influenced by the velocity with which the air passed over the ground. Thus, taking the evaporation over a given space as 2 with a moderate breeze, it would be 3, and even 4 or 5, with a gale of wind.

In concluding the discussion, the hope was expressed that more attention would in future be paid to the preservation of the salubrity of the rivers of this country. The river Wandle was one of great interest, as from its proximity to London it had frequently been suggested as one of the sources of the supply of water. But it had been shown that its flow was subject to great fluctuations; and, taking the minimum quantity that had been recorded, 10,000,000 gallons daily, that would only be sufficient for the supply of 300,000 persons, or about one-tenth part of the population of the metropolis. The proportion of the rainfall flowing off by streams and rivers could not be determined by any system of averages, but only by many years' recorded observations upon a particular soil, in a particular district, and then these observations would not apply to any other case. Upon certain lands on the banks of that river, between January 1858, and September 1859, 23 inches of rain fell, at some periods as much as 1 inch in two or three hours, but none of that water flowed through the surface drains into the river. Between September and November 1859, 10 inches of rain fell, and only then did the water begin to find its way through the subdrains into the river. A rainfall of 30 inches had thus been evaporated or absorbed by vegetation upon drained land. That seemed to show that one of the effects of underdrainage was, by the increasing fertility given to the land, to create a greater demand for moisture. During a portion of the time over which these observations extended it was a dry season, there was plenty of sun, and luxuriant vegetation; whereas last summer probably one-half the quantity of rain would have supplied a larger amount to the springs and rivers in the district alluded to. In reference to the subject of land drainage, it was urged that for the purpose of vegetation deep drainage was not required. Provided the moisture was 30 inches under the surface of the ground, that was the most suitable depth. The late Mr. Tycho Wing had ascertained, by carefully conducted investigations and experiments, extending over large areas and continued for many years, that in dry seasons, when the permanent stream of water was below that depth, vegetation suffered; and in wet seasons, if that depth was much exceeded, then vegetation also suffered. It was admitted that there were many local considerations to be regarded, as to springs, soil, &c., which might render it desirable to drain to a greater depth; but it must be recollected that the great expense of drainage was not in the cost of the pipes, but in the labour of excavating and filling up the trenches, and this was greatly increased with increase of depth.

Feb. 19.—The paper read was "*On the Results of Trials of varieties of Iron Permanent Way.*" By F. Fox, M. Inst. C. E.

The author stated that he did not wish to be thought an advocate for the superiority of either of the systems tried over other plans, or of iron over timber for permanent way, under any and all circumstances: his object being merely to record the results of actual trials, and the conclusions to which they led.

In 1853 an experimental length of a quarter of a mile (double line) of iron way, on the principle of Mr. I. J. Macdonnell, M. Inst. C.E., was laid on the Bristol and Exeter Railway. It consisted of a continuous rolled-iron rail bearer, weighing on an average 83½ lb. per lineal yard, and 11 inches in width. The bearers were united by joint or saddle plates 30 inches long, weighing 50½ lb. each. The bearers had a rise in the centre of $\frac{9}{16}$ of an inch, and a rib or tongue was rolled on the upper side, which fitted approximately into the hollow of the bridge rail. The rails originally laid weighed only 53¾ lb. per yard. Between the rail and the bearer a thin packing of pine wood was placed, the grain being in the direction of the length of the rail. The rails, the bearers, and the joint plates were bolted together, the distances between the intermediate bolts being so arranged as to admit of a rail being readily turned by unscrewing the nuts, or of a new rail being put in without opening out the ballast. Transoms or cross-ties of angle-iron were placed at average intervals of 12 feet between the two rails, and of 24 feet between the two lines. This system differed from the Barlow way, in having the rail or wearing surface separate and easily removable from the bearing surface; but on the other hand it considerably exceeded the Barlow rail in weight. After a wear of more than seven years this length of iron way was in good condition, and bid fair to continue so for some time to come. About one-third of the rails proved defective within the first two years, and had been replaced by rails weighing 60 lb. to the yard. The ballast which was very indifferent, being a loamy gravel, had been well drained, and a thicker packing, laid with the grain transversely to the direction of the rail, had been introduced. The bearers and joint-plates, transoms and rails, were supplied at £7 per ton delivered; and the cost per single mile of this arrangement, exclusive of the cost of matching and laying, was £1936. The cost of a single mile of the longitudinal timber way at the same period, taking the rails at the same weight and price, was estimoted at £1850. It should be mentioned that iron was then low in price, whilst timber was high. Owing to the undue lightness of the rail, both of these calculations were below the cost of a well-constructed permanent way.

As this experiment appeared on the whole to have been successful, it was determined to extend the trial, by laying 1 mile of double line on this system, at a further distance from a station, so that all the trains should pass over it at full speed. Some modifications were however made. The width of the bearer was increased to 12 inches, and its thickness was reduced to $\frac{9}{16}$ of an inch, so that its weight was 75 lb. per lineal yard: at the same time the curvature was slightly increased: the pine packing (creosoted) was thicker, and at the rail-joints pieces of hard wood laid with the grain lengthwise were substituted. The rails weighed 68 lb. per yard. The contract for the bearers, joint-plates, and transoms was taken at £9. 10*s*. per ton, the cost of the rails being £9. 8*s*. 8*d*. per ton. This length was laid in July 1857, where the line had not long before been re-ballasted with hard clinker ballast. The cost of a single mile, exclusive of laying, amounted to £2511. One mile of timber way, laid with the same section of rail at the same time, cost about £2254.

As these trials appeared to give a reasonable expectation of the greater durability and diminished cost of maintenance of the iron way, the author felt justified in recommending a further trial on a more extended scale, and on different districts of the railway. As the rolling and straightening of the curved section of bearer was alleged to be difficult, it was decided to adopt a flat section. The bearing surface was increased to 13 inches, the centre rib was rolled ½ an inch deeper, and the weight was thus brought up to 84 lb. per yard. Rail joint plates of a similar section to the bearer joint plates, were bolted underneath the bearer at every rail joint. Although this addition had been found advantageous, the way was still weaker at the rail joints than at any other part. Additional intermediate bolts were used, so that the upper and the lower sections of the way were held together as a girder. The contract for the bearers, joints, and transoms, was taken at £9. 12*s*. per ton; and the rails being £8. 13*s*. 1*d*. per ton, the cost per single mile was £2571.

In order to test the comparative strength of the different sections of bearer, of rail and bearer combined as laid, and of the rail and bearer joints with and without joint plates, a series of experiments was made, the results of which were given in a tabular form. The distance between the points of support was 5 feet. Of the three sections of bearer only, that of 1853 (the first) showed the least, and the flat section of 1859 the greatest deflection, under a load of about 5 tons; but in each case the ultimate strength did not exceed 7 tons. Of the three sections of iron way complete, that of 1853 was the weakest, and the curved section of 1857, with a rail weighing 68 lb. per yard, rather the strongest. The ultimate strength was reached under loads varying from 19 to 21 tons. An experiment with the flat bearer showed, as was expected, the increased stiffness gained by placing the centre rib downwards, thus practically deepening the girder. The ultimate strength of the timber way was ascertained to be 28½ tons, or 50 per cent. higher than the iron way. It was therefore determined still further to increase the section of the iron bearer. In this case the width of the bearer was 12 inches, and it was stiffened by a web underneath 3 inches deep and ¾ of an inch thick (a plan which was claimed by Mr. W. Bridges Adams). The weight was reduced to 76 lb. per yard, and the contract for this section was taken at £9 per ton. To stiffen the rail joints (which had no plates underneath), and to secure the ends of the rails, an iron plate having a tongue rolled on it was used. This section of way had been laid too short a time to warrant any decided expression of opinion of it, as compared with the other sections; but as a length of between 4 and 5 single miles was under trial, it would soon be seen if it possessed any advantages. It was perceptibly stiffer to travel over, and the middle web gave it a firmer hold in the ballast than either of the other sections. The cost of a single mile was £2385. This section was the fourth modification of rolled-iron bearer under trial, the entire length being 14¼ single miles.

The partial failure of the Macdonnell way on the Bridport railway was then referred to; and it was asserted that it arose from the rails and bearers being too weak, and from a disregard of those appliances which the character of the gradients, curves, ballast, and subsoil rendered more than ordinarily necessary.

In May 1858, a trial length of a single half-mile of the cast-iron sleeper way of Mr. De Bergue, was laid in immediate continuation of the Macdonnell way, and on the same kind of clinker ballast. Whilst still preferring a continuous rolled-iron to any cast-iron way, the author felt bound to state that not a single sleeper had been broken, the nuts of the bolts did not work loose, the rails wore very well, and with the exception of a little depression at the fished rail joints, the line kept as good a "top" as could be desired, and was as easily maintained, but was more rigid. The cost of this arrangement per single mile was £2103, or £300 per mile less than the Macdonnell way of the same period.

The merits and defects of the continuous rolled-iron permanent way were thus stated. The defects, or supposed defects, appeared to be:—1. The great cost, at present prices, almost precluding its adoption on a railway of limited capital. 2. The difficulty of getting the bearers rolled. 3. The possible increased wear of the rails. 4. The greater "wash" of all but very good ballast, inseparable from all iron ways resting on or near the surface. And, 5. The difficulty of laying on sharp curves, and of keeping in place when laid.

Its presumed merits were:—1. Greater economy in the long run, owing to increased durability: it was estimated that the cost of renewal of the longitudinal timber way was £45, and of the iron way only £21, per single mile per annum, or less than half, without reckoning the considerable item of labour in the replacement of the timbers. 2. Saving in maintenance, and facility for packing, owing to no "opening out" being required. 3. The safety of the iron way, especially as contrasted with a timber way which had been long laid. 4. The facility of changing worn rails. 5. The preservation of correct gauge. 6. The lowness of the crown of the rail above the bearing surface. 7. Saving in the depth of ballast in the case of a new line. And, 8. The equableness of the motion, rendering it probable that less injury would be sustained by the rolling stock.

Feb. 26.—The evening was occupied by the discussion upon Mr. Fox's paper on "*Permanent Way.*"

It was observed that the systems of permanent way described in the paper did not differ materially from the continuous iron way proposed by

Mr. Reynolds many years ago, which had been tried and failed. Looking to the effects of frost, floods, and heavy rains, and to the great variation in the quality of the ballast, a continuous flat iron plate laid on the surface was never likely to be successful in carrying heavy locomotives at high speeds. For a long time to come either the transverse sleeper or the longitudinal timber systems would probably be used, as they were not liable to be so much affected by the settlement of embankments, from whatever cause arising, the washing away of ballast, or the effects of frost. There might be occasions when it would be desirable to adopt some other mode than laying the line upon wood: as, for instance, when time was an object, and timber could not be obtained so quickly as iron, nor yet perhaps so cheaply. As the prices of materials varied very much at different times, comparisons of cost were practically valueless. The permanent way of railways ought to be the most perfect in construction, and the most conducive to safety and to ease in travelling, whatever might be its cost. It was wrong to continue to use the same sizes of sleepers and scantlings of timber that were first employed, as the engines were now thrice the weight, and the speed had been doubled. To make a road fit for the description of locomotive and rolling stock at present in use, and to travel at the same speed, at least double the sum ought to be expended. The permanent way and the rolling stock could be made so as to be as safe for speeds of 70 miles as of 30 miles an hour: it was merely a question of money, there being no mechanical difficulty about it whatever.

It was said that the conclusion to be drawn from the summary of advantages and disadvantages, which had been most fairly stated by the author, was the complete condemnation of iron permanent way. There was no advantage in first cost, and the maintenance was certainly more expensive than with a timber road, which would be free from the disturbances likely to affect the iron way laid upon the surface of the ground. There was also greater rigidity, and this told in two ways—first upon the "life" of the rails, and secondly upon the rolling stock. The other systems of permanent way might be divided into three classes: 1st, longitudinal timbers, with a bridge rail or a modification of it; 2nd, transverse sleepers, with a double-headed rail and chairs; 3rd, transverse sleepers, with a bridge rail, or a modification of it. The latter system was well adapted for light traffic, was inexpensive, and easily maintained. Either of these roads, when properly constructed, would enable the highest speeds required in a commercial country to be attained with safety.

Attention was then directed to the comparative difference in the wear and tear of rolling stock and of rails, upon a rigid road, and on a road that was more elastic. And the many tires broken during the late frost, though no doubt in some cases attributable to an indifferent quality of metal having been used, had been caused, it was asserted, in many instances by the rigidity of the permanent way.

It was stated that the Reynolds way consisted of a continuous cast-iron trough, very different in principle to the flat wrought-iron sleeper described in the paper, in which the results of experience on one of the best maintained lines in the kingdom had been given, speculative opinions having been carefully avoided. The different roads alluded to by the author had been observed to keep in good condition in all weathers and under all circumstances; and the testimony of careful enginemen, who could generally point out any radical defects in the permanent way, was in favour of this form of iron way as compared with the longitudinal timber system. At the same time it was admitted there were serious difficulties to be overcome in every form of iron road yet proposed. It was important that the system of permanent way adopted on each railway should be capable of being laid throughout the whole length of the line, and of being carried through stations. It was doubted whether the continuous wrought-iron way was applicable in stations, or where there were points and crossings. The De Bergue cast-iron sleeper presented greater facilities in this respect, but a road laid on these sleepers had not the flexibility of a timber road. One of the things which gave the greatest trouble in most kinds of permanent way was the movement of the rail in its bearing. This was prevented in the De Bergue system, as the sleeper was bolted firmly to the rail, and formed in fact a bracket or extension of it. In a timber road this evil might be much diminished by reducing the number of fastenings; and in this respect the ordinary single-headed contractor's rail, fastened direct to transverse sleepers without chairs, was to be commended as being simple, inexpensive, and effective.

It was contended that practical men in charge of railways invariably preferred transverse sleepers to longitudinal timbers; and it had been found that upon the whole the annual expense of maintenance was less with the former system. Thus, upon the road between York and Darlington, which was laid upon transverse sleepers, the joints of the rails being fished, 2 miles were maintained for the same sum that it cost to maintain 1⅓ mile on the longitudinal timber system. The rigidity of the permanent way during frost was due very much to the want of thorough drainage in the road. By the use of creosote the "life" of the sleeper was not terminated by its decay, but was dependent upon the period it would bear the usage it was subjected to. If the permanent way had to be constructed without reference to economy, which had not been the case hitherto, then no doubt great improvements would be made. It had been found advantageous to seat the double-headed rail, when using the ordinary chair, on a cushion of wood, endways of the grain. This plan prevented the indentation of the underside of the rail, and the motion of the trains over the line was easier. Steeling the surface of the rails had also proved very beneficial. The cost of applying this process did not amount to more than 14*s.* per ton, and the durability of the rails was at least doubled as compared with rails made in the ordinary manner.

It was mentioned that the plan of placing a wooden cushion in the chair under the double-headed rail had been tried many years ago on the London and Birmingham line, and was not found advantageous, as, unless frequently renewed, the rails wore through them. In England the double-headed rail was almost universal, excepting on the Great Western and a few other lines; but on the continent of Europe and elsewhere a deep or broad-bottomed flange rail was most generally used; and it was to be remarked that these lines had been constructed after experience had been gained in this country, and in many cases under the direction of English engineers. From this it was inferred that the use of the chair, which had hitherto constituted the great difficulty with double-head rails, would in future be avoided. In forming the seat for the chairs, the scantling of the sleeper, which in most cases was already too small, had to be still further reduced, so that where the greatest strength was required in the support there was the least. Attention was then called to Mr. Seaton's system, in which a saddle rail, laid on the apex of triangular timbers, forming a continuous bearing for the rail, was employed. Immediately under the joints of the rails a plate was bedded into the timber by pressure, so as to make the joint equally solid with the other parts of the line. This road had been laid on the London and North-Western (at Bletchley), on the South-Western and on the Great Western railways; and it had been found that the first cost was something less than the double-headed rail system.

It was considered that, as regarded cast and wrought iron roads, as far as experience had gone at present, both had proved unsuccessful. The addition of an elastic medium between the support and the rail, as described in the paper, might however be the means of lessening the rigidity, and thus removing the great defect hitherto attaching to iron roads.

It was remarked, that engineers were now aware that a certain amount of elasticity was necessary in the permanent way of railways. Experience seemed to prove, that the transverse sleeper road, with the joints of the rails "fished," was the best; and that if chairs could be dispensed with, it was advisable; but the means of fastening the foot-rail to the sleeper were not what could be desired. It had been ascertained that during the frost there was less destruction to the rolling stock on lines that were fished than where that was not the case. With reference to the mode of fishing, recently, on two short lines where a flat-bottomed rail weighing 62 lb. to the yard had been employed, the rail-joint had in one case been fished to the sleeper, and in the other the fish was suspended; when it was found that the difference was in favour of the fish attached to the sleeper.

It was said that all the forms of cast-iron sleepers yet tried were unsuitable for many kinds of ballast, such as hard broken stone, flint, or other unyielding materials; and that it was doubtful whether wrought-iron bearing plates laid on that description of ballast would form a pleasant road to travel over, unless an elastic medium were introduced between the rail and the bearer. Several objections were taken to the continuous rolled-iron rail-bearer; for instance, that in passing round curves, and at stations amongst points and crossings, it would be difficult to bend the bearer laterally in the same degree as the rail, and to match the lengths of the rails and the bearers so as to make the bolt-holes always correspond, and thus avoid the necessity for drilling fresh holes. The best form of transom for the longitudinal way was asserted to be a flat bar of iron, placed vertically, so as not to take a bearing on the ballast, leaving that duty to be borne by the bearer; as otherwise when the road got out of order, a series of jerks was produced on travelling over the line, in consequence of the increased resistance at these points. It was contended that though the use of iron as a rail-bearer was still in its infancy, yet in this land of iron it was fair to conclude that improvements would be made in its application to this special purpose, and that iron ways would ultimately become the rule rather than the exception.

The statement, that whilst the weight of engines and trains and the speed of travelling had been increased, the permanent way had not been proportionately improved, was thought to be capable of some modification. Twenty years ago locomotive engines averaged 15 tons in weight, supported on four wheels; now the weight was doubled, but there were six wheels; and the greatest weight on the driving wheels rarely exceeded 12 tons. In the same time the running speed, which was what told on the permanent way, had not been increased more than 25 per cent. On the other hand, looking to the permanent way itself, the rails now in use, taking the London and Birmingham line as an illustration, weighed 84 lb. to the yard against 65 lb. at the former period, and the chairs 45 lb. instead of 25 lb. each. There was also one more sleeper in each rail length, and the joints of the rails had been strengthened by the addition of "fishes." Only a small proportion of the unfortunate accidents that had occurred on railways of late years could be attributed to weakness of the running road. They seemed rather to be due to the giving way of some part of the rolling stock. On these grounds, the asserted insufficiency of the present permanent way, and the necessity for doubling the cost at the outset, were disputed.

In reply to the observations which had been made, it was remarked that the greater portion of the iron ways alluded to in the paper had been in use eight years, which, although perhaps not a sufficient time to allow of a decided opinion being expressed, was surely enough to enable some opinion, founded on experience, to be given. It had been said that the systems described by the author had been tried and rejected upwards of twenty years ago, and Reynolds' hog-trough cast-iron sleeper was cited as a case in point. Now the continuous rolled-iron rail-bearer only resembled that plan in this respect, that iron and wood entered into the composition of both systems. Mr. Reynolds' sleeper was a rigid continuous trough of a **V** shape, bolted at the joints, and absolutely inflexible, although the hollow was filled with a wooden cushion; whereas the rolled-iron way was only too flexible. It was urged that, speaking from speculation and not from experience, Mr. Greaves' cup-sleepers might be condemned, as there was rigid iron resting on sleepers of the same material placed immediately on the ballast. It was said by engineers who had tried them, that they gave a great deal of trouble, and that the sleepers sucked up water from the ballast. There was a great difference between flexibility and compressibility. The term "rigid" had been frequently made use of in the course of the discussion. From experiments it could be shown, that between 5 feet bearings the double-headed rail deflected less, and was more rigid, than the Macdonnell system; but as the double-headed rail was placed upon timber sleepers, forming a compressible cushion, it was not rigid; and for the same reason, the rail on the Macdonnell system being laid on a cushion of wood, which it might be desirable to increase, was not rigid in the sense of flexibility. In fact the forms first tried were too flexible, and that had led to the use of the **T** section bearer. It could be stated as a fact, that the maintenance of the Macdonnell system on the Bristol and Exeter Railway cost less than the other portions of the line, in the proportion of about half a man per mile. Taking that at £20 per annum, it would be equivalent to the interest upon the additional outlay at the first outset. With regard to the action of frost upon the iron way, it was admitted that was one of the difficulties of the system where the ballast was bad and the line was not well drained. But upon clinker ballast no difficulty of that kind had been experienced, although on another part of the line, where the ballast was composed of particularly bad gravel, it had given some trouble. In reference to Mr. Seaton's road, it was feared that it would be liable to work loose at the joints; and although, looking at the way the timber was cut to form the continuous bearing, it appeared at first sight an economical mode, yet the edges of the timber were liable to be destroyed, and then the width of the bearing would be practically reduced. The difference between the Barlow rail and the Macdonnell system consisted in the interposition of the elastic cushion between the rail and the bearer in the latter; when that was removed the bolts worked loose. The rails could easily be replaced, when required; but they had not been observed to wear out faster upon the iron way than upon the timber way. The rails and the bearers were punched at regular intervals, so that in putting in a new rail it could never be necessary to do more than cut off a short piece at the end; and as to the drilling, it did not cost more than one penny per hole, which would only amount to a small sum per mile. The system had been laid upon a curve; and in that case the difficulties which had been suggested were got over by making the bearers in short lengths, and having a greater number of joints. Many of the bearers were bent in the rolling process, and these were selected for the curves. As to the transom taking a bearing, that was not the case, because the transom was hollowed out. A **T** rail transom was preferred to a thin bar, because if the latter received a side blow it would be likely to draw in the gauge. The different systems of iron way which had been tried over several years, were so far not a failure that they might be pronounced to have been to a considerable extent successful.

In concluding the discussion, credit was given to the author for the candid, practical spirit brought to bear upon the subject. At the same time it was thought that iron permanent way, at the present moment at all events, was not one which could be safely recommended. All roads laid upon embankments, or in cuttings, were liable to subsidence in a varying degree. It was impossible to believe, having a due regard to economy and efficiency, and to the fact of engines weighing 30 tons travelling at from 50 to 60 miles an hour, under all the extremes of weather, of wet and of frost, that any system of permanent way could answer in the end which was not laid to a sufficient depth in the ground. The result of 25 years' experience went to show that the double-headed rail, made of good materials, with properly proportioned chairs, and the joints of the rails effectively "fished," was as near to perfection as could be practically attained. In the construction of railways, the permanent way was that which perhaps had been the least attended to; and the greatest difficulty had been experienced in getting the consent of boards of directors to increase the expense of the way, in order to insure its efficiency. The hope was expressed that this discussion would have the effect of convincing boards of directors that some additional expense must be incurred in providing better materials for rails, sleepers, and chairs than it had been hitherto possible to get them to sanction.

March 5.—The first paper read was "*Description of a Pier erected at Southport, Lancashire.*" By H. Hooper, A. Inst. C.E.

This pier was constructed at right angles to the line of promenade facing the sea, on an extensive tract of sands reaching to low-water, a distance of nearly one mile. Its length was 1200 yards, and the breadth of the footway was 15 feet. At the sea-end there was an oblong platform, 100 feet long by 32 feet wide, at right angles to the line of footway. The superstructure was supported upon piers, each consisting of three cast-iron columns, and each column was in three lengths. The lowest length, or pile proper, was sunk into the sand to the depth of 7 feet or 9 feet. These piles were provided at their bases with circular disks 18 inches diameter, to form a bearing surface. A gas tube was passed down the inside of each pile, and was forced 4 inches into the sand; when a connection was made with the water company's mains, a pressure of water of about 50 lb. to the inch was obtained, which was found sufficient to remove the sand from under the disk. There were cutters on the under side of the disks, so that on an alternating motion being given to the pile, the sand was loosened. After the pressure of water had been removed about five minutes, the piles settled down to so firm a bearing, that when tested with a load of 12 tons each, no signs of settlement could be perceived. The upper lengths of the columns had cast-iron bearing plates for receiving the ends of the longitudinal lattice girders, each 50 feet long and 3 feet deep. The centre row of girders having double the duty of the outside ones, top and bottom plates were added. The weight of wrought-iron work in each bay was 4 tons 5 cwt., and of cast-iron work 1 ton 17 cwt. The second bay from the shore was tested by a load of 35 tons, equally distributed, when the mean deflection of the three girders in twenty-four hours was 1½ inch, and there was a permanent set of ½ inch on the load being removed.

The advantages claimed for this mode of construction were:— 1. Economy in first cost, especially in sinking the piles, which did not amount to more than 4½*d.* per foot. 2. The small surface exposed to the action of wind and waves. 3. Similarity of parts, thus reducing the cost to a minimum. 4. The expeditious manner of obtaining a solid foundation—an important matter in tidal work. Two hundred and thirty-seven piles were thus sunk in six weeks.

The estimated cost of the pier and approaches was £10,400. The works had been completed for £9319, being at the rate of £7. 15*s.* 4*d.* per lineal yard. The pier was designed by Mr. Brunlees, M. Inst. C.E., and the superintendence of the construction was intrusted to the author, as resident engineer; Messrs. Galloway being the contractors.

The second paper was "*On the Construction of Floating Beacons.*" By Bindon B. Stoney, A. Inst. C.E.

The various forms of floating beacons hitherto employed were first referred to,—including, among those whose axis of symmetry was horizontal or oblique, the barrel and the can buoys; and among those whose axis of symmetry was vertical, of which the cone might be considered the typical form, the bell beacon of Liverpool, the nun buoy, and the egg-bottomed buoy. All these buoys were characterised by want of conspicuousness and by instability. These defects had however been greatly remedied by Mr. Herbert's Cone-bottomed Buoy (*vide* Minutes of Proceedings, Inst. C.E., vol. xv., p. 1). In this arrangement it was originally proposed that the mooring-chain should be attached either to the centre of gravity, or to the centre of the plane of floatation. But this was said not to have been attained in practice, as the mooring-chain was fastened to a point nearly half-way between the plane of floatation and the lower edge of the buoy, and considerably below the centre of gravity. If it were fastened to the centre of the plane of floatation, the author believed the buoy would become much inclined under the influence of currents in the opposite direction to the current, from the lateral pressure being below the centre of mooring, in place of above it, as was usually the case.

Being aware that additional keels or bilge boards tended to prevent ships of certain forms from rolling, by the inertia of the mass of water constrained to move along with the ship, and that advantage had been taken of this circumstance in some light ships, the author suggested that a similar arrangement might be applied to a floating beacon, and the result was the Keel Buoy. The superstructure might be of any of the ordinary forms, the dome-shaped being preferred for conspicuousness. The sides were prolonged below the bottom, so as to form a circular keel, within which a large body of water was contained. Thus, a buoy of 6 feet diameter with a keel 18 inches in depth, would contain a mass of water weighing about one ton, or the same weight as the buoy. The bolt of the mooring-chain, where it passed through the mooring-ring, divided the surface exposed to lateral pressure into equal or nearly equal portions. Hence, the keel buoy would float erect in tideways or river currents, as an equal pressure was exerted both above and below the centre of mooring. The keel also gave this buoy a greater hold in the water, and the tendency to pitch was diminished. It also acted as ballast placed in the best position to secure stability. In consequence of the peculiar form of the keel buoy, and of its stability, the superstructure might be 25 per cent. higher than that of other buoys of equal diameter, with the same configuration above the water. The mooring-ring had a shank, which projected through an aperture in the wrought-iron bottom. It was firmly rivetted on the inside of the bottom, so that the straining of the chain could not tear it away, or loosen the rivets. The author believed that in the keel buoy there was a greater freedom from abrupt motion than was possessed by other floating bodies having the same amount of displacement. If a buoy were made very wide in proportion to its height, and with slight immersion, it would float upright, because it would float like a board on the surface of the water; but stability thus gained would be at the expense of manageableness. If, on the other hand, stability was sought for, not by breadth of beam, but by ballasting the bottom, the buoy would not only be unwieldy but expensive. The keel buoy was light, was easily handled, and on board ship only occupied so much room as was sufficient for it to stand on end; thus contrasting favourably with the can and egg-bottomed buoys.

In the course of the *discussion* a regret was expressed that the paper contained no details of the experience of the use of the keel buoy, and that there was so little additional information to what had been given in Mr. G. Herbert's paper in 1855. It was contended that it was incorrect to call the circular prolongation of the casing "a keel;" that no comparison could be fairly instituted between such a casing and the usual bilge pieces, and that what was called the keel could not have the material effect attributed to it by the author. Also, that the keel buoy was so trifling a modification of the cone-bottomed buoy introduced by Mr. Herbert, as not to be entitled to any great degree of merit; and that the latter was the stronger form of construction, as the strain of the mooring-chain would be upon the cone, whilst in the other it must be resisted by the flat diaphragm, or bottom of the buoy. The cone-bottomed buoy was extensively employed by the Trinity Corporation, as well as by foreign governments, and only two instances were known where such beacons had been injured by breaking from their moorings, and then they were destroyed by being thrown among rocks. At Liverpool, buoys so constructed, 20 feet in diameter, and standing 20 feet out of water, safely rode out the late gales, and on no occasion had there been the slightest failure in that respect.

The beacons made use of by Admiral Sir Edward Belcher, in the survey of the western coast of Africa, were likewise alluded to. A cask of 60 gallons had a spar driven through it, which projected 3 feet on the upper side, and 9 feet below. To the upper end a topmast was fitted, and the lower end of the spar was ballasted in such a way that the beacon always maintained a perfectly erect position in very strong currents and tides.

NOTES ON ROMANESQUE ART IN THE SOUTH OF FRANCE.[*]

By J. B. Waring.

Some friends have suggested to me that it would not be unwelcome if I were to give to the Institute a few notes which I made during a late trip through France, mostly concerning matters relating to architecture; and although I am fully aware how very slight and superficial they are, still some of my brethren in art may find them of interest and of use in future days. And now that a complete line of rail joins Paris with Marseilles, Marseilles with Toulouse and Bordeaux, and thence by Angoulême and Poitiers to Paris again, such a trip becomes merely the pleasure excursion of a summer holiday. The main object of these notes will be to direct attention to the Romanesque sculpture and architecture of the south of France, as seen in some of the cities of Provence, Languedoc, and the adjoining districts.

Leaving behind us the noble examples of Mediæval art at Seur, Dijon, and Auxerre—which last, as regards its architecture, painted glass (thirteenth and sixteenth centuries), and very beautiful sculpture, will repay the tediousness of a trip *en voiture* —we will make Lyons our starting-point. It is true that there is not much here in the Romanesque style, but what there is is very interesting. The principal monument is the abbey church of Ainay, a cross church, with an entrance tower, and a lower tower over the dome. Parts of this building, including the entrance tower, have been ascribed to the Carlovingian period. Experience has led me to be very diffident as to assigning dates without very good authority; and, although parts may be of an earlier epoch, the entrance tower may I think be safely assigned to the early part of the eleventh century. The entrance is by a Pointed arch, with details of a more decidedly Roman character than can be found elsewhere in the work, and is possibly an insertion at a later period. The rest of the building is plain and massive: the internal archivolts are not moulded, and the dome, which rests on angle squinches, is supported by antique columns cut in half, to which the other columns of the nave are roughly assimilated. Like other ancient monuments in France, it is undergoing complete restoration. The insertion of red tiles as an ornamental feature, so remarkable in the tower, is to be seen again in the façade of the bishop's palace, a portion of which (now blocked up) still remains; and as this corresponds with similar Romanesque arcades of domestic architecture in France, all very much of the same class, we may take the approximate date above given as by no means too early. The sort of acroteria to be seen at the angles of the tower have been supposed to indicate a very early date, but that this is no certain criterion may be judged from the fact, that they occur also on the tower of St. Radegonde, at Poitiers, which may be ascribed to the latter part of the eleventh or the beginning of the twelfth century.

Of the old church of St. Pierre only the portal remains in its original state: well designed and massive, it appears to be a work of the eleventh century, and exhibits the large cusping so frequently seen on the Romanesque churches of the Rhone and of Central France. St. Paul's still retains a good octagonal belfry and apse of this style. It is needless to dilate on the Cathedral, or on other well-known Pointed buildings of this city, but I would add, that no one should fail to visit the Museum, which has been lately enriched by a most interesting collection of works in ivory, enamel, metal, &c., bequeathed by M. Lambert; amongst which the statuette in ivory of the Virgin, seated, and holding the infant Saviour in a vesica piscis in her lap, is prominently remarkable. It is solid, about 14 inches high, and opens so as to form a triptych, containing panels, with a central Crucifixion and subjects from the life of the Saviour in relief. A similar portable statue of the Virgin is preserved in the museum of the Louvre, and given in Leduc's 'Dictionary of Furniture'; but that of Lyons appears of somewhat earlier date, and may be ascribed to the end of the twelfth century.

From Lyons to Avignon, following the course of the Rhone, there is little that bears on Romanesque art. At Vienne the towers of St. Andre le Bas, and the desecrated church of St. Pierre, are good examples of their class. Amongst the few old bits left in the Cathedral I would draw notice to the external arcade on the north side,—to a curious pilaster, in the interior, which is remarkable as exhibiting angular hollows, formerly filled in no doubt with coloured substances, of the same character as seen on Childeric's sword-sheath at the Louvre, on the lately-discovered Spanish offertory crowns at the Hotel Cluny, and on the Anglo-Saxon brooches, &c.—to (also in the interior) a very curious frieze formed by the signs of the zodiac,—and to some very rough and mutilated statues in the lateral porch (north), pleasing to antiquarian eyes. I would not leave Vienne without asking attention to the large cuspings of the tower of St. Pierre, similar in character to those on the portal of St. Pierre at Lyons, just mentioned, and so usual in Auvergne, for it is the last time we shall find them on our way south. And this leads me to remark, that I do not think that any influence came from the south into Auvergne; but, on the contrary, that the French archæologists are right in making Auvergne one of the great centres of Romanesque art, the waves of which, decreasing in power as they spread in circumference, died away about this point in a southern direction.—The cathedral at Valence is undergoing complete restoration, and its curious porch is closed to the public; the interior, however, and the apse with its chapels, appear to belong to the early part of the eleventh century; everything here is plain and massive, and the choir, with its stilted arcade, has a peculiarly Hispano-Moresque character, though I believe this arises only from the constructional necessities.—With the exception of its magnificent Roman remains, Orange has little to detain the architect: the only portion of the cathedral not modernised is the south side porch.

We now come to Avignon, that queen of mediæval towns, with its grand old palace, quaint towers, crenellated walls, frowning portals, chapelled bridge, the broad and rapid Rhone, and crested rocks, above all of which rises like a protecting spirit the venerable cathedral of Notre Dame des Dons. The early date to which this building has been ascribed by some authors (among whom I believe is Mr. Fergusson), cannot I think be founded on any good ground; the portal shows the appliance of materials from some late Roman work to its present purpose, and is no indication of peculiar antiquity in a district where Roman remains are common, and their re-adjustment in new work pretty frequent; as to the body of the building, its masonry, arrangement, detail and construction resemble so closely other works in France acknowledged to be of the eleventh and twelfth century, that we are justified in classing it amongst them, and my own impression is that no part of it can be ascribed to an earlier period. Near the altar is preserved the curious and interesting marble chair used by the Popes. The back is mitre shaped, and the sides are carved in low relief with the winged lion and the winged bull. The first Pope who reigned at Avignon was Clement V., in 1305, and the chair would appear to belong to this period. A more ancient but less attractive relic of ecclesiastical art is to be found in the altar-table, supported by five columns—four angle and one central. It is one of the few examples of this class of early altar that has come down to the present day almost uninjured. There are other interesting subjects in this picturesque building; but the place is so dark as to render it almost impossible, unless perhaps on a bright summer day, to get satisfactory drawings.

---

[*] Paper read at the Royal Institute of British Architects.

Avignon is an excellent point from whence to make several most interesting excursions, and amongst them I would particularly recommend a visit to Villeneuve les Avignon, for its very perfect citadel and noble entrance gateway, and the rich and beautifully carved monument to Innocent VI., in the chapel of the Hospital, consisting of three most delicately carved pinnacles of open work, over an altar tomb, on which is the recumbent effigy of the pope, with his feet resting on a lion: it dates about 1360.

Proceeding down the Rhone, the next interesting Romanesque work is the small chapel on the heights above Beaucaire, belonging to its ruined castle; it consists of a plain barrel-vaulted hall, entered by a round-headed portal under a square tower, with lean-to sides. The openings to admit light are very small, round-headed, and plain beaded. The masonry, of the usual good Romanesque character, consists of smallish square blocks neatly worked, the corbels and arch bands forming the principal ornamental feature. The interior is now completely gutted, and serves as the abode of the concierge.

At Tarascon, on the opposite bank, we meet with the first indication of a complete change of style in the south porch of the Cathedral, rich in mouldings and ornament—dog-tooth, flower, ovolo, and nail-head, with ample columns, and a once richly-carved frieze (now quite destroyed), above which runs a blank arcade and sculptured string-course, exhibiting unmistakably the influence of the Arlesian style. The date generally ascribed to it, that of the close of the twelfth century, is probably a correct one. I may here remark, that perhaps nowhere is the influence of local styles more clearly defined than in the south of France. At Avignon and Nismes we have a close approximation to late Roman work, with pediments, columns, and friezes; the mass being plain. At Arles, St. Gilles, and Tarascon, deeply-recessed and many moulded portals, richly sculptured; and at St. Trophime, Montmajour, and St. Remy, cloisters of a distinct type. At Narbonne, Carcassonne, and Toulouse, the single broad-spanned interior and long lancet windows of a later date are quite peculiar; and the Romanesque buildings of Toulouse, with their high and many-staged brick towers and angle-headed openings, are of a marked local character.

But let us return to Arles. The interiors of the churches here are very simple, and of the usual Latin cross plan. At St. Trophime the piers are plain and square, the caps flat and roughly worked, the archivolts plain and semicircular; between them are corbels supporting piers with angle colonettes, from which spring the plain flat bands of the barrel-roof. But it is to the sculpture that I wish particularly to allude. The centre of the portal contains the Saviour and the emblems of the Four Evangelists, with the Twelve Apostles below, the archivolt being ornamented with rows of ministering angels. The great frieze represents, to the right of the Saviour, the good led to heaven; and on his left, the wicked strung together with a rope and dragged by the devil to hell: beneath these are large statues of the Apostles (the Four Evangelists being on large lion pedestals), the statue of St. Trophime, the Martyrdom of St. Stephen, and the Ascension of his soul to Heaven. On the sides of the porch are, to the left, Adam and Eve at top; beneath them, an angel weighing the souls of men in scales; beneath that, the devil holding the condemned upside down, which seems to have been a favourite idea of punishment with the sculptors here: under this again, along the pedestal of the columns, is a large reclining nude figure, but with an animal's skin above his back; he holds a lion on another side of the pedestal by the hind leg,—this subject, the man however being dressed, occurs in the same position at St. Gilles, and clearly means Samson. On the other return of the porch are represented goats, a ram, dog, &c., probably symbolic of wickedness; beneath which stands a great fiend, holding his victims upside down and in other unpleasant attitudes; he stands upon a dragon: and beneath the whole are the flames of hell.

Let us now enter the cloisters, the capitals of two sides of which are historiated, or carved with scriptural and legendary subjects and foliage. The angle panels of the piers on entering are carved with the Saviour's Ascension, angels at the tomb in the centre, soldiers sleeping at the tomb beneath: on the return are, above, the three Maries; Judas receiving the price of blood beneath. At the next angle, to the left, are angels emerging from the clouds; the Transfiguration in the centre, the Disciples beneath; on the return, the Martyrdom of St. Stephen, to whom the church was originally dedicated. At the next angle, the Kiss of Judas, the Last Supper in the centre, and the Saviour washing the Disciples' feet beneath; on the return, the Temptation on the mount, and below, John baptising the Saviour.

Such are the principal subjects portrayed on this building; and they are so interesting in point of subject and style, the date also being probably posterior to the year 1152, when the remains of St. Trophime were transferred here, that I would place by their side some notes from other sacred buildings of the same period, and by the comparison we may arrive at some suggestive conclusions. I propose also to separate from this class of sculpture that represented by the corbels, which, when brought together and compared, will open, I think, another view of their particular meaning.

We are now standing before the three very richly-sculptured portals of St. Gilles, about 15 miles south of Nismes, similar in style to St. Trophime, but more profusely ornamented, the round-headed entrances being rich in column, moulding, and ornament. In the centre is the Saviour, seated in an oval aureole, on a rainbow in the clouds (heaven), his head encircled with a glory of alternate star-point and flame. Round him are the usual emblems of the evangelists. The left semicircle contains the Adoration of the Magi; the right, the Crucifixion. Beneath there runs a great frieze containing the Life of the Saviour; beneath this is a band containing crouching animals—lions, bulls, and others, and human heads. On each side of the great entrance are two evangelists on lion pedestals, and four apostles to the right and left of them. On the extreme right and left, carved on the wall, are two archangels, standing on and spearing the dragon and the enemy of man respectively. The small subjects on the pedestals represent Samson, Cain and Abel, centaur and stag; an old lioness and her young, disturbed by a figure now destroyed; David and Goliath; and David feeding sheep; other smaller and less important subjects are partly scriptural and partly symbolic.

At Moissac we have another very interesting sculptured portal, in the abbey church of St. Peter and St. Paul, also a work of the twelfth century, the arches of which are broad Pointed. The entrance consists of a recessed porch, on the left side of which are represented, at top, a figure pointing to a scroll, meaning probably, "It is written;" next to him is Lazarus represented in grave-clothes, and of infantine size (as departed spirits are always shown), resting on Abraham's lap; then comes Lazarus reclining (but of the same size now as the other figures), with dogs licking his wounds, and angels watching over him; then Dives feasting at table. Beneath these are large groups of devils punishing Avarice and Lust; the soul of the miser is being carried off by one demon, while his bag of money is taken from him by another, he is on his deathbed, and his wife vainly weeps over his corpse, whilst grinning demons watch his death-throes; beneath are two large figures of the devil seated on the miser's shoulders, grinning horribly, whilst by his side a naked woman has her breasts sucked by serpents, whilst from the mouth of the demon by her side springs a toad. Amongst the monstrous corbels of this kind may be remarked also a goitred cretin head, popular belief of that day having adjudged this unfortunate people to be the devil's own. Two of the caps on this side have amongst the foliage, demons with bellows fanning the fires of hell, torturing the condemned. There is a certain grotesque horror about all these figures which may have served in early times to have impressed the beholder with fear and awe. This is the side of the wicked, and on the opposite wall is represented the salvation of the good. First, at top, is the Flight into Egypt—Mary and Joseph approach the city gates, and the idols fall from the high places, as narrated in the apochryphal gospels; next comes a group, apparently the Return to Palestine; beneath is shown the Adoration of the Magi in two groups; and below these the Annunciation, and the meeting of Mary and Elizabeth. In the centre of the arch is the Saviour, in an aureole, with crown and nimbus; the winged animals of the Revelation, symbolic of the four evangelists, seraphim, angels, and ten elders with lutes and vases, or, as it is described in Revelation, "Having every one of them harps and golden vials full of odours, which are the prayers of the saints," these are all surrounded by clouds, indicative of heaven; the remaining fourteen crowned elders, with lutes and vases, minister beneath to the Lord, forming a frieze or sculptured lintel; on the left of the doorway is St. Peter with the keys; and on the right, St. Paul, probably, with a scroll inscribed, "Ecce virgo conferet" ("Behold a virgin shall conceive"—the prophecy of Isaiah vii. 14). The central pier of alternate lions and lionesses resting on each other's backs, and with a figure without the nimbus at each return, holding one a book, the other a scroll, I do not pretend to explain. The external mouldings and splays of the arches are carved with separate single pieces in relief of fruit, leaf, fish (some of which have the heads of ducks and foxes), birds, and lastly (next the door angle) animals, the whole forming together a sort of epitome of the creation.

Although out of our immediate province, I cannot pass by the richly-carved cloister of this abbey without remarking also a curious illustration of the book of Revelation, found on two capitals: one is formed by the symbols of the evangelists, a cable necking, scroll angles, and an abacus carved with foliage, and eight lions with their tails intertwined; on the other cap an angel descends from a cloud (heaven), and leads a dragon captive by a chain, with the inscription, "Serps anticus qui est diabolus;" whilst, on the other side of the cap, after his thousand years' imprisonment, he issues forth from the porch of his prison to meet two men, who appear to receive him with upraised hands expressive of astonishment or fear; under the dragon is written "Golitah," under the men "Gog and Magog" (see Revelation xx.); the necking is a plain torus, and the abacus ornamented with scales and foliage. This is merely mentioned as evincing a connected idea and appropriate ornament. The subject of sculptured capitals would carry us into a wide disquisition; my own impression is that a complete investigation would prove that certain subjects were chosen as a general rule, and applied to different parts of the sacred edifice—doorways, windows, capitals, bases, and corbels, each having certain classes of subjects adjudged to them, either by absolute rule or traditionary custom.

We will conclude this, I fear, dry catalogue of subjects on the Romanesque façades, with a brief notice of St. Croix, at Bordeaux, probably of an earlier date, *i.e.* of the eleventh century.

The extrados of the centre arch is carved with angels; next come the elders crowned, and worshipping with music and incense (harp and vase) a central figure at the apex, intended for the Lord; the next broad band has the beginning of the zodiac, but this was apparently a mistake of the workman, and was never carried out; after this comes a row of kneeling figures pulling a rope which binds together two seated figures at the apex, probably the marriage of the Saviour and the Church. On the arch to the left Avarice is represented in five groups, each consisting of the miser and the devil in various stages of downward fall; and on the right arch are five groups representing Lust, each of a woman—clothed, not naked as at Moissac—with an attendant demon and the usual toads and serpents.

The first thing to be remarked in this enumeration of subjects is that in the main they are entirely scriptural—illustrations, in fact, of the Old and New Testaments. The Virgin Mary never is found as a prominent figure, and legendary subjects are not usual. The great points are purely Christian, such as the glorification of the Saviour, Lord of heaven and Judge of this world, as described in Revelation; and the power of the apostles, amongst whom, naturally, the evangelists are especially honoured. Besides this scriptural sculpture we have moral sculpture, reading a lesson and holding out a warning to what the church considered the two great vices, of avarice in man and lust in woman; a very *naif* and curious illustration of what the priesthood naturally considered most innate with each sex, although our own sex did not always escape reproof, as shown by the very coarse and matter-of-fact illustrations of lust to be seen in the churches of St. Paul at Narbonne, St. Sernin at Toulouse, and St. Jean at Valence. We have also symbolic sculpture, such as the small pedestals of columns at St. Gilles and at Arles, in which bears, lions, centaurs, &c. play an important part. Without going to the extent of Durandus, Cahier, Lewis,* and that school, it is impossible to deny I think a meaning more or less definite to these apparently fanciful subjects.

Concerning the style of art shown in these works, it is most decidedly of a Byzantine type. In the earliest, such as the very curious marble reliefs round the choir of St. Sernin at Toulouse (probably of the ninth century), the folds of the dresses are few and raised in a crease: this method holds good at Moissac (three centuries later), although the heads of the figures naturally show a great advance in art. At Arles and at St. Gilles the folds are minute, peculiar, and of strongly marked Byzantine character, and this is more evident on a statue in the Museum of Toulouse, preserved from a destroyed church there, and which, besides its value in point of execution and style, is interesting as being signed by the sculptor Gilibertus or (as he signs himself on another statue) Gilabertus. My impression is that these works were chiefly executed by French sculptors after a model or illustration given to them, which, if not actually Byzantine, was formed on a Byzantine sample.

The figures on the façade of St. Croix at Bordeaux are most curiously Assyrian in character; the same remark holds good to some portions, especially drapery, of the sculpture on the cathedral at Angoulême; and it is a question whether Greek or other workmen were not actually employed on some portions. Mr. Lewis (this time it is our excellent secretary that is meant) in his very interesting paper on Arab architecture, speaks of the impressment of all kinds of workmen by the Spanish Moors; and it is not unlikely retaliations took place on the part of the Christians, or that Greek workmen (then the most skilful of their time) were here and there employed expressly.

The subject however which most took my attention in these Romanesque churches was the corbel, since its explanation was the most difficult, and I believe has been but little considered by archæologists. Let us compare some of them. First, on the façade of the Beaucaire chapel we have a goat's head, a cock's head, a leaf, an eagle, a lamb, a leaf, a lion with a human head in its mouth, a monster (mutilated), and a demon's head roaring, nailed to the corbel. Next, at the cloister of Montmajour, near Arles, a bear, a goat, a bull, monster human heads, a leaf, a lion's head with a human head in its mouth, and a lion's head devouring a small naked human figure. Then, in the cloisters of St. Trophime, a goat, a figure (man) in somersault, a bird much mutilated, but apparently a cock, a running figure, a donkey's head and neck, a lion with a human head in its claws, a female figure in somersault, a lion, an angel, and a long-horned goat. And at St. Gilles (façade) a small angel in foliage, a human head in foliage, a ram, an eagle with a sheep in its claws, a lion's head, a bull, a running figure, and a leaf. The corbels on the façades of St. Trophime are nearly the same as those in the cloister. Now I am not going to assert that nothing but these subjects are found on the corbels of the Romanesque churches; for, not to mention numerous others, at Moissac alone may be remarked a man and woman kissing, a figure holding its mouth open with its hands, a head with water apparently over one eye; one figure laughing, another scratching his head, a fox, monsters, grotesques, and foliage, which hardly can seriously bear interpretation—I mean scriptural interpretation. But it does seem most probable that these animals and figures, so constantly repeated, allude to the animals present at the birth of Christ; and that the peculiar bars sometimes seen on the corbels, as at St. Sernin at Toulouse, and Notre Dame at Clermont, represent the manger.

Indeed, most of the minor incidents connected with the birth and youth of the Saviour are seen; just as at a later date the accessories of the Crucifixion, the sponge, the nails, &c. were brought into use. The domestic animals are those present at the birth; the ass bore the Holy Child into Egypt (at Arles it is represented kneeling); the falling figures, male and female, are the gods and goddesses that fell at the Child's approach; the angel in foliage appeared to the wise men of the East; the running figures are the messengers from Herod, the lions with figures or heads in the mouths and the claws are Herod, as temporal power, destroying the infants; the monster heads are enraged demons whose doom is now come; and the nailed devil's head, which occurs at Beaucaire, at Arles, and later still at Dijon, where he has a ring in his mouth, typifies his fall through the birth of the Holy One.

---

* Not the hon. sec. to the Royal Institute of British Architects.

However this may be, a most interesting collection of sculptured corbels might be made, the result of which would be, I think, to show that the earliest examples bear directly or indirectly on the birth and youth of the Saviour; that other subjects were gradually introduced until they became as varied as at Moissac; and that when the Pointed style took shape and gave greater scope to the individual sculptor, new ones were introduced at will, whilst the old traditionary subjects were still retained. Thus, in the Cathedral at Poitiers (dating early in the thirteenth century, a most noble monument of the Early Pointed style), we find in about three hundred corbels of the interior, a mass of purely secular subjects, sometimes characterised by a power of caricature and broad fun which would be worthy of a modern pantomime.

Having just allied the lion's head with temporal power, I cannot refrain from saying a few words on the lion, and his meaning in Romanesque sculpture. We must remember that the lion may symbolise several things, and that it is necessary to discriminate his meaning by his position and attitude. Taking St. Gilles only, we find him, on the band running beneath the Life of the Saviour, slinking and crouching with his head to the ground and his tail between his legs; he is also in company with tigers, serpents, and dragons; whilst human heads with an intense expression of fear turn away from him: he is here the Evil One, roaming about like a lion, seeking whom he may devour, but crouching in subjection and fear beneath the feet of the Saviour and his Apostles. Now the lion, as we know, in a secular sense always signifies force or power; the Byzantine emperor on his throne with moving lions, is minutely described by historians. The mediæval judge had his seat "inter leones;" and the lion's head, head and claws, or entire body, occur universally on thrones, &c., as allied with power secular and ecclesiastical. We are then, I think, justified in taking the lion with a human head or figure in his jaws or claws to typify the abuse of power. At St. Gilles the four Evangelists stand on moulded brackets which rest on lions' backs; and although one is too much injured to make out, yet we have still remaining three of these lions of the church. Two of them are tearing to pieces human figures —a woman and a man—which I take to represent a heathen god and goddess; the most perfect is a man naked to the waist and thence clad in a sort of antique trowser; there is no mistake here, the lion savagely clutches one arm with his mouth, and with his right paw, the claws well out, drags the naked flesh in the man's side in strongly marked creases; the man's head is unfortunately broken off, but beneath it, and proceeding may-be originally from his mouth, creeps away a draconite creature, symbolic of the Evil One escaping from his hold. Next to this a lion holds a lamb (or ram rather, for I believe it has horns), he however does not in this case destroy, but protects, resting one paw with claws retracted on the sheep's back, and the other on his head; it is clearly an attitude of protection, and the head is placid: here we have the Lion of the Church ready to defend the Christian ("Ye are my sheep") who rests evidently happy and at ease beneath his fostering care. The bases of the small columns of the left doorway rest on two lions *couchant*, who with reverted heads gnaw at the base; this is probably the power of the wicked, which the church keeps down, but which is for ever biting its bonds. Besides these interpretations we shall find the lion sometimes employed as a type of David (the Lion of Judah), and also not far removed from any figure of Samson or Daniel. I say not far removed, because the old sculptors were not very particular in keeping the lions of the heroes together, as may be seen at St. Trophime and St. Gilles, in the case of Samson, and on the porch of St. Porchaire, at Poiters, and in the cloisters at Moissac, where, if my memory does not deceive me, the lions are shown on one side and Daniel on the other. On the St. Porchaire portal, at least, Daniel is in an aureole, with angels overhead, on a capital to the right; and the lions on a capital to the left, with the inscription, "Daniel inter leones."

(To be concluded in our next.)

RESTORATION OF CHICHESTER CATHEDRAL.

An influential public meeting, presided over by the Earl of Chichester, was held on the 21st ult. in the Town-hall, Brighton, for the purpose of organising a movement for the restoration of Chichester Cathedral; when the Duke of Richmond read a report from Mr. Geo. Gilbert Scott, upon the present condition of the edifice, the extent and character of the repairs it requires, and their probable cost.

The report stated "That the tower and spire have ceased to exist, and in their fall have carried with them the first bay or compartment of three out of the four arms of the cruciform structure—namely, one compartment of the nave, and one of either transept. Towards the east the two piers which supported the tower still exist to a certain height, and the adjoining compartment of the choir has consequently been preserved as high as the base of the clerestory, above which it has fallen. The eastern piers have also sustained in some degree the adjoining portions of the eastern walls of the transepts, though these are much shaken, and their upper parts in a great degree destroyed to the extent of their first compartments. It is a remarkable and very happy circumstance that, in a disaster so tremendous as the fall of a steeple of nearly 300 feet in height, the destruction of the adjoining parts of the building should have been so limited in its extent; and the more so, as the same infirmity of construction which has led to the disaster, pervades in a greater or less degree other portions of the edifice. It was however inevitable that a concussion so violent, and the sudden removal of the centre of the cross, on which all its arms in some degree trusted for steadiness, must have a very injurious effect upon the building. Accordingly there are symptoms here and there throughout the building of the rude and sudden shock which it has sustained; and even where these are not visible, but where the fabric has been long suffering from injuries and defects of far earlier date, there is strong necessity of a thorough substantial reparation, as it is clear that an ancient and defective structure, though it may remain long without showing symptoms of danger while suffering from no special cause of disturbance, can by no means be viewed as being in the same position after the fall and rebuilding of its great central feature. Within less than a century after its original building it was most severely damaged by fire, and its present architecture mainly consists of the portions of the old structure which escaped, overlaid by the later work by which the injuries were then repaired. This ancient injury was no doubt one cause of the weakness which seems to pervade the older portions of the building; and even now the effects of the fire may be seen in the triforium galleries, in the ragged, discoloured, and half-ruinous condition of the stonework.

This state of dilapidation—increased as it had become by the lapse of time—would have soon demanded general reparation had no accident occurred to shake the building; but under circumstances so extraordinary as those from which it is now suffering, its permanent safety imperatively demands that every structural defect should be made good. The roofs also, particularly that of the choir, and those of the aisles both of the choir and nave, demand very extensive reparation, as their present most defective condition exposes the walls and vaulting to continued injury. The first thing however which demands attention is the immediate security of the four arms of the cross. In their present exposed and unsupported state it is impossible to consider them as safe; indeed, any sudden gale, acting at once on the internal as well as on the external surfaces of the walls and roofs, might produce some serious increase of the damage already sustained. This danger being now effectually provided against by substantially shoring up the different portions, any attempts to economise in this part of the work might lead to serious and costly failures. Till this has been effectually carried out, the heap of *débris*, which now acts as an abutment to the great arcades of the church, ought not to be removed below its present level.

In rebuilding a tower which is to form the central abutment of four arcaded arms, which were never very firmly built, and which, through the effects of fire, of age, and of a shock such as that which they have now sustained, are in a condition far from substantial, it is of the utmost importance to lay its foundation so firmly, and to construct its walls of materials so immovable, that if possible no settlement at all should take place during its erection; and, at the same time to render it so selfsupported, that instead of trusting for its own abutment to the arms of the building, it should afford to them the support which they require, without bringing any pressure upon them. To effect this the work must be done in a much more massive way, and with better materials than is necessary in an ordinary work. The foundations must be carried down, at whatever cost, to a stratum of undoubted firmness. They must be spread unusually wide, and be constructed of large and massive materials, laid in the hardest cement. The piers and arches must be of solid and closely-jointed block stone, and that of great hardness and strength; and the whole carried out with an excess of strength beyond what, in an ordinary structure, would be deemed necessary. No soft stone or rubble work should be admitted in any part of the work. This will naturally increase the cost, but it is necessary to its safety, and particularly to the permanence of the remainder of the building. The same remarks apply to the bays adjoining the tower, which will have to be rebuilt—including of course the first bay of the choir, which, though not wholly destroyed, must of necessity be taken down.

It is needless to particularise the defects in and the repairs required by the different parts of the building. The parts which are in the most critical state appear to be the transepts. It is desirable to save every fragment of the original structure which is consistent with the security of the whole, as the renewal of any part detracts seriously from its interest; but there can be no doubt that these parts will demand the most careful treatment to render them permanently secure. In the estimate of the cost of restoration, every part has been supposed to be an exact transcript of what is lost. There may be cases where a wise discretion should be exercised in this respect, as it may not in all cases be reasonable to reproduce in exact detail a work whose design was the result of alterations, repairs, and reconstructions, spreading over many centuries. In the repairs of existing parts, strength and security rather than architectural restoration have been considered.

The probable cost is as follows:—

The rebuilding of the tower and spire	£25,000
The rebuilding of the four adjoining bays	12,000
The necessary repairs of other portions	7,000
The cost of shoring up and of providing temporarily for the services	2,000
	£46,000

When to this is added the cost of superintendence, and of other incidental expenses, it would be unsafe to reckon upon an outlay of less than £50,000."

After the reading of the report the meeting was addressed by several speakers, and a unanimous determination was expressed to accomplish the object in view. Resolutions were passed, confiding the work to Mr. G. G. Scott, appointing a general and various local committees, and constituting the Duke of Richmond, Mr. H. Hollist, and the Rev. John Gurney trustees of the fund.

REVIEWS.

On the Condition of the Niagara Railway Suspension Bridge. By John A. Roebling, C.E.—Trenton, N.J. 1860.

The doubts which have been recently entertained respecting the strength and stability of the new suspension bridge over the Niagara Falls, are too well known to require explanation as to their causes and removal. We are also acquainted with the opinion entertained by Mr. Barlow respecting this question, which is the result of direct observations made by him during a recent visit to the United States. The bridge, as all are aware, was opened in the early part of the year 1855 for railway traffic.

In order to arrive at a definite knowledge whether there really existed any foundation for the doubts in question, the directors of the Niagara Falls International Bridge Companies called upon Mr. Roebling to institute a series of experimental observations on this bridge, which was originally constructed by him. The result of these examinations is embraced in a report which forms the contents of the pamphlet under notice. Mr. Roebling tells us that, after a careful examination of all the parts of the bridge, he is not prepared to report any material changes in the condition of the structure which could influence its stability and durability. It will not be uninteresting, perhaps, to note here the results produced by a series of experiments which were undertaken with the object to test the stiffness of the structure. Five trains were made to traverse the bridge successively, in such a manner that the deflections produced by the passing load could be ascertained with accuracy. The first, a train weighing 35 tons, and consisting of an engine drawing a tender and ten empty cars, caused a deflection in the centre of 0·462 feet. The second train, consisting of a smaller engine, two loaded passenger carriages, a luggage van, and a van with cattle, deflected the bridge 0·540 feet in the centre; and the third, a light engine with five loaded passenger carriages and a baggage van, 0·520 feet. In the fourth instance, a single engine with tender crossed the bridge, and produced 0·315 feet deflection. In the fifth, the same engine returned with eight loaded cars, each containing seventeen to eighteen cattle of the largest size, and deflected the bridge 0·789 feet in the centre.

It will be observed that a short and heavy train, as in the last instance, produced the greatest deflection comparatively—a deflection which is, however, not materially different from those produced by the experiments in 1855. As the proportion of the actual strain on the cables to their ultimate strength is as 1 to 5·30, it will be seen that there is a liberal allowance to insure their durability. Mr. Roebling, after pointing out that no material advantages could be gained by running the trains over the bridge at high speeds, owing to the fact that a station is situated at each extremity of the bridge, comes to the conclusion that a greater speed than five miles per hour for passenger trains should not be permitted. Notwithstanding this, should circumstances necessitate a higher speed in general, a further expenditure of 20,000 dollars would be sufficient to render the stability and stiffness of the bridge such as to admit of goods trains passing over it at the highest practicable speed without the slightest injury to the structure.

The woodwork, the author says, if properly attended to will last for forty years or more. Adducing some instances to prove that this can and will be the case, Mr. Roebling recurs to the durability of the cables, and makes this question the subject of discussion of the physical properties of wrought-iron in general. It has been contended that a bar subject to vibration or tension is liable to molecular change, or so-called granulation or crystallisation,—this fact, however, has in no case been satisfactorily established. On the contrary, Mr. Roebling maintains that iron or any other metal can never undergo the process of crystallisation when in a cold state. Indeed, to produce this change the presence of heat is necessary. He further refers to those properties of iron which are of the first importance in its various appliances. In all instances where the material is exposed to great tension, as well as to torsion and vibration, it should be composed of iron which not only possesses great cohesion, but hardness and elasticity. As a proof of this opinion he has recorded several facts which have come within his own experience. They refer chiefly to various old bridges in the United States, the ironwork of which, after having been exposed to the influences of weather and changes in temperature for many years, has proved to be equal to the best iron manufactured at the present day.

In considering the strength and stability of the Niagara Bridge, it must be borne in mind that this structure is not subject to vibration, and further, that the working strain of the cables does not exceed one-fifth of their ultimate strength. That there is therefore sufficient ground to convince us of their durability, Mr. Roebling estimates it at not less than several hundred years.

Railway Communication in London, and the Thames Embankment. By C. B. Lane, C.E.—London: J. Ridgway, Piccadilly.

Without committing ourselves to an entire approval and recommendation of the plans suggested by the author for the relief of our fellow-citizens from the constant dead-locks and obstructions which occur in the metropolis, and the consequent injurious retardation of the commerce and intercourse of this vast city, we must say that this pamphlet demands an attentive perusal, and that its suggestions have a more practical tendency than those contained in most of the pamphlets of a similar character which have come before us.

The author draws attention to the fact that, as the terminal stations of the existing railways are at present situate, they must necessarily tend more to increase the evils of street obstruction than to lessen them. For example, the distance of the greater part of the present terminal stations of the railways from the eventual destination of the passengers and goods thereby conveyed necessitates the employment of additional vehicles, as cabs and railway-vans, in the passage from the station to the desired locality. This latter conveyance consumes not unfrequently more time than is occupied by the train itself on its run to town. The principle considered by the author is that all those stations which are at present *terminal* should become *through* stations, which he looks upon as the only effectual means of relieving the streets of London from the immense traffic. This will be realised to a certain extent by the Metropolitan Railway, which will bring, so to speak, the Great Western, the London and North Western, and the Great Northern Railways, into the heart of the city. It will be further promoted by the connection of the above line with the Eastern Counties Railway by the branch through Finsbury, as well as by the extension of the London, Chatham, and Dover line to Ludgate-hill. However, our author still conceives this insufficient, and proposes a high-level railway from the Blackwall line, near the Minories, which, leaving it, would curve to the south, cross over Thames-street and the north end of London-bridge to the river side, and run along the proposed Thames embankment to Westminster. From Westminster station the line would turn to the west, run through Pimlico, alongside the Crystal Palace Railway, and finally join the Kensington Railway near its southernmost extremity, thus connecting stations south of the Thames with those north—a short branch line near Temple Gardens connecting the proposed line with the Metropolitan Railway. The author maintains that a *high level* railway alone will answer the required purpose; and concludes his pamphlet by pointing out that such line, if executed as suggested, would supply the deficiencies still existing in the Metropolitan line as proposed by Mr. Fowler.

The Strains on Structures of Ironwork; with Practical Remarks on Iron Construction. By F. W. Sheilds, M.Inst.C.E.—London: Weale. 1861.

The present may justly be called an age of iron. If we want a ship large enough to carry the population of a parish half round the world and back again, or strong enough to laugh at the broadsides of a hostile squadron, iron only will serve our turn. If we would throw a bridge across a river two miles broad, to carry the stream of traffic between two great territories, there is nothing for it but iron. If the demand is for a house that can be packed up and sent to the antipodes, or for a transparent palace in which treasures of art and industry from every corner of the world can be adequately displayed, still the material must be iron. Subservient to almost every purpose, this useful metal puts new facilities of construction within our grasp; it also imposes new conditions, and infuses into both design and detail a character altogether of its own. Well understood, and fairly handled, no material can be more thoroughly depended upon. But the very largeness of the trust reposed makes it a matter of vital concern, not only that the metal and the workmanship should be of perfect quality, but that the engineer or architect should bring to the study of his design a complete scientific and practical knowledge of the subject.

Those who have been long conversant with iron structures, and have a large personal experience to draw upon, may be little in need of consulting books. But there are many who, without much previous practice in this especial department of construction, have on occasion to try their hand at it, and feel the need of a clear and trustworthy handbook. To the pupil again, while nothing can supply the place of observation of actual work in every stage of progress, a sound and lucid theory is invaluable; observation becomes the keener and the more intelligent, and memory the more faithful and methodical, just in proportion as the principles of construction become familiar to the mind.

But perhaps it would not be easy to point out a book which furnishes exactly what is wanted on this subject. Elementary works are sometimes, perhaps, somewhat too elementary, and scientific works are often too exclusively scientific. The very points on which the young professional man may especially seek light may be altogether left untouched; sometimes because it is taken for granted that the reader understands them, and sometimes because the writer does not set forth in sufficient detail all the assumptions on which his reasonings are based.

Mr. Sheilds tells us in his preface that when he was appointed in 1852 to assist the principal officers of the Crystal Palace Company, at Sydenham, in calculating the strength and designing the details of the company's works, he found great difficulty in acquiring a complete knowledge of the strains on the several parts of iron framings; "as the works of previous authors, though displaying great talent and research, have left much undetermined or obscure which is necessary to the designer of such structures." Mr. Sheilds was therefore thrown much on his own resources in mastering this difficulty. He, however, acknowledges the assistance derived from an able friend (the late Mr. C. H. Wild); from the perusal of Mr. Clark's well-known work on the Britannia Bridge; of Mr. R. H. Bow's treatise on Bracing; and of a paper on Diagonal Braces by Messrs. Doyne and Blood, read at the Institution of Civil Engineers. It may be remarked that Mr. Bow's work on Bracing was written to meet the same want that our author expresses himself to have felt, in regard to the special study of iron structures; and deserves just credit as the effort of an unassisted mind to elucidate a difficult subject.

The result of knowledge gleaned from these and other sources, digested by independent thought, and matured by the practical experience of several years, is presented in the treatise before us; and we think we may congratulate Mr. Sheilds on having made a very acceptable addition to a class of books of which the lack is more and more felt every day.

The first section treats of the strains in framed girders of uniform depth, braced in the triangular or "Warren" fashion. Our author regards the transmission of the load to the piers on the usual principle, which has the recommendation that it is of old prescription, gives true results, and, although not the simplest possible, may be easily understood with a little study. The principle is shortly this: every part of the load is to be considered as deriving its support from both piers; the proportionate support derived from each pier being inversely as their distances from the loaded point. Thus, if a girder of 100 feet span had five points loaded with 10 tons each, at the distances of 10, 20, 30, 40, and 50 feet respectively from one pier, the portions transmitted to the piers of each of these loads would be as follow:—The load at 10 feet distance would derive 9 tons of support from the nearer pier, and 1 ton from the further pier. The load at 20 feet would transmit 8 tons to the nearer pier, and 2 tons to the further pier. The next load would be divided into 7 tons for the nearer pier, and 3 tons for the further pier. The next, at 40 feet distance, into 6 tons and 4 tons; and the last load, being in the middle, would depend on each pier for the support of half its weight, or 5 tons.

In calculating the strains on this principle it becomes necessary, when a load covers several points of a girder, to take the weight on each point in detail, to divide it as just explained, and work out the strains it throws on each part of the girder; having gone through this process for each portion of the load in succession, and found the separate strains, it only remains to add these partial strains, and their sums will be the actual strains which the whole load brings upon the girder. In this way of looking at the question, the currents (if we may so speak) of pressure transmitting the several portions of load from each point to either pier, through the action of the braces, are constantly crossing each other. Thus, many of the braces will undergo at once strains of compression and strains of tension; and it is necessary to find which of these opposite kinds of strain preponderates, and by what amount, in order to determine whether a brace is acting as a strut or a tie, and how much work it is really doing. When some or all of the load is movable, regard must be had to the greatest strain of compression or tension to which any part of the framework is liable under a possible disposition of the load, and adequate provision made to meet it.

The whole method is very lucidly and thoroughly set forth in the treatise under review, with one or two plain and useful rules for shortening labour by generalising some of the details of the process.

In the following sections (paragraphs 18—21) the strains on cantilevers are dealt with, very briefly. The reasoning is correct, but there appears to us to be a slight inaccuracy in detail in the following passage (par. 20). The cantilever is supposed to be loaded at its extremity c—

> "The strains on the end bay next the weight at c, are equal to the greatest strain as found above, divided by the number of bays; and the strains on the other bays commencing from c are respectively twice, thrice, four times, &c., the strain on the end bay next c, increasing in

regular proportion from *c* to *a*. Upon the shorter flange *db*, however, the strain on the end bay *c*, as found above, must be multiplied by 1½, 2½, 3½, &c., to give the strains on its bays in succession, commencing from the end *d*."

It appears on examining the action which really takes place (see Figs. 1 and 2) that it is the end bay of the *shorter* flange which has the horizontal strain 1 thrown on it, since a pair of braces meet in the point *d*. While the end bay of the *longer* flange undergoes a strain only equal to ½, resulting from the action of the single brace, which terminates in *c*. Thus, in the above figures, the number of bays being 5, the common factor is $\frac{\mathrm{WL}}{5\mathrm{D}}$; and the proportional numbers for the longer flange *ac* are ½, 1½, 2½, 3½, and 4½ (the compression of the last strut *a* being discharged on the pier.) The proportional numbers for the shorter flange *bd* are 1, 2, 3, 4, and 5.

Fig. 1.

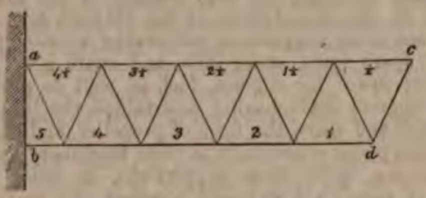
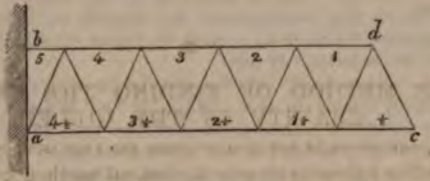


Fig. 2.



Again, in par. 21 a similar correction seems needed. When the cantilever is loaded at each point from *c* to *a*, the effects on the bays of the longer flange *ac* should be given as ½, 2, 4½, 8, &c.; instead of 1, 3, 6, 10, &c.; and the effects on the bays of the shorter flange *bd* as 1, 3, 6, 10, &c., instead of 1½, 4, 7½, 12, &c.

These, however, are points of detail merely: the general principle is in the main clearly and correctly laid down.

The important subject of Continuous Girders is then touched upon. Here Mr. Sheilds simply gives the reader some of the more important results of continuity without attempting to show how these results are proved. In this he has done wisely, since the process of proof involves more abstract mathematical reasoning than could suitably be introduced in so elementary as well as practical a work. Those who wish to dive to the bottom of the subject may accomplish their wish by reading the investigation in the work on the Britannia Bridge.

We think, however, that tacit assumptions should be avoided as far as possible, since the learner is very apt to be misled by them. We therefore could have wished that *all* the suppositions upon which the definite results are based had been given, and none left to be inferred. These suppositions are: 1st, that all the spans are equal; 2ndly, that the load on every span is equally distributed over it; 3rdly, that (unless where otherwise expressly mentioned), all the spans are loaded alike; 4thly, that all the girders are equally rigid; lastly, that every girder is of uniform depth and rigidity throughout. It is important that this last condition (uniform rigidity) should not be lost sight of. An unequal distribution of metal in the flanges of a continuous girder (such as is sometimes made for the sake of economy), alters the position of the point of contrary flexure,—and recourse must again be had to mathematics to find it.

It would also have been very useful to say a word or two as to the proportionate strain which occurs over the pier, as compared with the amount of strain on the centre of a girder not continuous. When there are only two spans, the girder sustains over the pier a strain equal in amount (although opposite in kind) to that which the girder of either span would sustain at its centre, if disconnected. In this case, therefore, the maximum strain is in no way reduced by making the girders continous, but only transferred to a different point. It seems very necessary to keep this fact distinctly in view. Railway girder bridges of two spans even now exist in which the continuous construction of the girders has been held to justify an exceptionally slight section.

We concur in all that our author says as to continuous girders of two and of three spans. But in par. 24, while correctly stating what happens in the case of three spans, he makes the same statement apply to cases of more numerous spans. In this we cannot agree. If we remember rightly, clear rules are given for various numbers of spans in the work on the Britannia Bridge. A broad general deduction from the case of three spans is hardly admissible.

After a sound and useful investigation of Parallel Girders with Vertical Struts, we come to a discussion of the more difficult subject of Bow and String Bridges. The strains are dealt with geometrically, and with as much simplicity as the principle of the subdivision of weights, already adverted to, admits of. The question of the Bow and String Bridge with triangular bracing is very satisfactorily handled. In par. 37 is a little slip, which it would be as well to correct:—"and from *f* draw also by scale a vertical $fg = \mathrm{W} \times \frac{n}{\mathrm{N}}$; W being the weight on one loaded point, N the total number of bays, and *n* the number of bays which *e* is distant from pier 2." We should read "from pier 1," since the weight which *fg* measures is that which is transmitted to the pier 2, and is proportional to the distance of *e* from the other pier.

The treatment of the Bow and String Bridge with both vertical and diagonal bracing, a more complicated problem than the last, is not on the whole quite so clear and satisfactory. Indeed there are points which might be revised with advantage. If Mr. Sheilds will look over par. 40 and Fig. 24, he will find that in computing the tension of the brace *sc* he has taken the weight transmitted through the vertical strut *bs*, but omitted the weight at the point *s*, a portion of which is taken by the brace in question.

On plate girders and other descriptions of girders there are some sound practical remarks, which would well admit of amplification. In particular, some general directions would be useful as to the thickness of web of plate girders. An admirable paper by Mr. Heppel on the strains of the plate web was read before the Institution of Civil Engineers a year or two ago, and is printed in the Transactions. In speaking of the proportion of length to depth of girders, Mr. Sheilds has, however, fallen into an error on the subject of rigidity. The rigidity of a rectangular bar of a given *breadth* increases as the *cube* of the depth. The rigidity of a rectangular bar of a given *area*, or of a girder of a given *section of flange*, increases as the square of the depth. The rigidity of a girder of a given *ultimate strength* increases *simply* as the depth. We therefore cannot endorse the following statement.

> "It is important, however, to state that the rigidity of the structure is proportionate to the square of the depth; consequently, though the ultimate strength remains the same, the deflection increases very rapidly as the depth is diminished. Thus, in two girders of equal span and loading, and of the respective depths of one-tenth and one-fifteenth of the span, both constructed of proportionate strength to resist the strains upon them, and both loaded to the point of fracture, there would be equal weights required to break them down, but the deflection of the one would be fully double the deflection of the other."

This is quite a misapprehension. The rigidity of the supposed girders would be simply as their depths; and their deflections under any given load, and (consequently) their deflections under the breaking load would be inversely as their depths; that is to say, as ten to fifteen. The ultimate deflections of girders of a given span, whether equally strong or not, are always inversely as their depths.

The author concludes with an explanation of the mode of computing strains in iron roof trusses, and gives what is very useful, namely, some diagrams of trusses, with the proportionate strains worked out in such a manner as to be readily applied to cases of any span.

We have been the more careful in commenting on various points that seemed to call for criticism, because we regard the treatise on the whole as a valuable one, both in intent and execution; taking the place of a handbook on a subject on which one has been much needed, and capable of being made the nucleus of a really valuable work. We hope Mr. Sheilds may have an early opportunity, in preparing for a fresh edition, of both revising and amplifying. A word or two on the proportionate sectional area of metal for given strains in different members of framing would be useful. Some details as to modes of forming the various junctions might be given: it would also be acceptable to many to be offered some hints on testing girders, on the questions of deflection and "set," on the maximum load to provide for in flooring, and on many other practical points as to which the reader might have the benefit of the author's experience.

The little work is got up in very creditable style.

Notes on Screw Propulsion; its Rise and Progress. By W. M. Walker.—New York: D. van Nostrand; London: Trübner and Co. 1861.

The remarks contained in this book, on the history and efficiency of the screw propeller, were originally published by the author in the 'Atlantic Monthly,' an American nautical journal, and have been lately re-issued, in consequence of their favourable reception, in a separate form under the above title. These notes, although bearing reference to screw propulsion in general, are more especially intended to apply to steam-ships of war.

Our readers are familiar with the early history of steam navigation—from the first introduction of paddles as the agent of propulsion, to the latest improvements of the screw propeller. As the first examples of more modern steam-ships, the author refers to the Minnesota class of frigates. These ships, although presenting few features that are absolutely new, are very far from being imitations of existing examples. The principal novelty, perhaps, which distinguishes these ships from others is the arrangement of their armament, a feature which has attracted the attention of the naval powers of Europe. The novelty we refer to is the great reduction in the number of guns, compensated for by employing guns of a greater calibre, with more space for working them advantageously; in addition, the number of gun decks is reduced from three and two to one, thereby diminishing the danger of lodging shells in small and limited spaces. Hitherto it has been the custom, especially in France and England, to measure the power of ships by the number of gun decks. The author thinks that for these reasons other nations will be slower in adopting the last-named principle than in introducing the larger calibre of the American ordnance.

In the construction of an efficient steamer of war, one of the first objects aimed at is to place the engines entirely under the water-line. In order to attain this end, the Admiralty enlisted the talent of the best constructors of this country, in consequence of which no less than fourteen distinct varieties of engines have been produced by various designers. Of those screw engines complying with such requirements, Penn's horizontal trunk engines appear to have met with the most favourable adoption, these having been placed in no less than forty different ships of war in the British navy. The power of these engines varies from 200 to 800 horses.

Another condition of a screw ship of war is a "fine run" of its after body, the necessity of which has been fully confirmed by the experiments undertaken with the Rifleman, the Sharpshooter, and other vessels, which underwent a gradual alteration in the after-lines, the speed being 24 per cent. in favour of the finer run. The author next urges the necessity that all war steamers should be furnished with the "trunk," or "well," into which the propeller can be raised when required by circumstances. This arrangement obviates the "dragging" of the propeller through the water, which would otherwise be a great impediment to the speed of the ship when under sail. It is true that the strength of the stern is somewhat impaired by the introduction of the "trunk," but the advantages derived from its use more than outweigh this objection, as will be seen by the fact that nearly all the screw ships in the British navy are supplied with a contrivance for raising the screw.

With respect to the most efficient speed for war steamers, the author maintains that great speeds offer on the whole less advantages than moderate speeds, inasmuch as the powerful engines required for effecting a high speed monopolise so great a space and displacement as to render it impossible to carry sufficient fuel for their proper development. This, he says, is proved by the fact that a ship running 1200 miles at the rate of ten knots per hour, may run 1800 miles with rather less consumption of fuel, but at the slower rate of eight knots per hour. Where men-of-war are intended for a short and intermittent service, it may be of advantage to furnish them with as powerful engines as possible; but for distant service, an economical consumption of fuel should be of greater consideration than high speed.

In conclusion, the author refers to some improvements which have been lately effected, relating chiefly to the working parts of the engines and boilers, such as the substitution of wooden for metallic bearings, the improvement of the draught of the furnaces by the introduction of fan blowers, &c.; and, finally, throws out some suggestions concerning a contemplated reduction of "spare spars, spare sails, and spare gear," in order to gain more space for engines, fuel, as well as provisions. He further suggests that—having ascertained the best proportions for the hull and spars, the form of propeller, and plan of engines of a certain power—vessels, with their machinery, be constructed in accordance with these proportions, in order that when a number of vessels are stationed together, the spare gear of one may be available for another ship. This suggestion, however valuable it may appear at the first glance, is, we fear, inconsistent with the character of a perfect man-of-war, which should contain in itself all that is required for its maintenance and independence.

◆

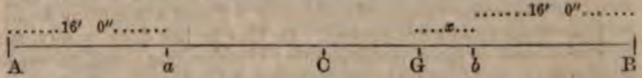
SIMPLE METHOD OF FINDING THE CENTRE OF GRAVITY OF THE GIRDER.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—The following simple algebraical method of finding the centre of gravity of the girder, for which a rather complicated arithmetical formula is given at page 63 of your last number, may not be uninteresting to some of your readers.

The girder is 64 feet in length; one-half is loaded at the rate of half a ton per foot, the other at 2 tons per foot. Let us take each half of the girder separately; the weights or loads per unit of length may be considered as a system of parallel vertical pressures, the resultant of which gives the position of the centre of gravity for each half of the girder. As each half of the girder is uniformly loaded, their centres of gravity will evidently be in the middle, that is 16 feet from each abutment.

To find the centre of gravity of the whole girder, we proceed as follows:—In the figure below let AB = the whole girder = 64 feet; C = its centre; *a*, *b*, = positions of the centres of gravity of each half respectively. Now making CB the end which bears the heaviest load, the centre of gravity of the whole girder will manifestly, from the nature of the case, be somewhere between C and *b*. Let it be at G.



Let $Gb = x$, $aG = 32' - x$; then since weight at $b = 4$ times weight at a, we have

$$aG : Gb :: 4 : 1;$$

or substituting the values for aG and Gb,

$$32' - x : x :: 4 : 1; \text{ or } 32' = 5x \text{ and } x = 6'{\cdot}4.$$

From above, $bB = 16'$, so $GB = 16' + 6'{\cdot}4 = 22'{\cdot}4$ and

$$AG = 64' - 22'{\cdot}4 = 41'{\cdot}6, \text{ the result obtained at page 63.}$$

I am, &c.

25th March, 1861. T. Cargill.

[Mr. Cargill is quite correct, and the simple rule he gives would undoubtedly be followed in finding the centre of gravity of the particular load referred to. The more comprehensive rule given in page 63 of this Journal for last month is, however, the only one applicable to every case of loading. The case being given for the sake of illustrating a universal rule, a special solution would have fallen short of the scope of the writer.—Ed.]

◆

Monument to Sir John Franklin.—The legislature of Tasmania have voted £1000 for the erection of a monument to the memory of Sir John Franklin, in connection with the improvements now being carried out on the fine site in Hobart Town on which stood the viceregal residence at the time the Arctic navigator was Lieutenant-Governor of the colony.

NOTES OF THE MONTH.

The Stone of the Houses of Parliament.—The committee appointed by the government to inquire into the causes and remedy of the decay in the stone used in the Palace of Westminster met on the 23rd ult. There were present Sir R. Murchison, Messrs. Tite, M.P., Sydney Smirke, G. G. Scott, G. Godwin, C. H. Smith, G. R. Burnell; Profs. Frankland, Hofmann, F. A. Abel, and Ansted; and Mr. D. Wyatt. The committee appointed Mr. Tite chairman; and Mr. A B. Carter is the secretary of the committee. The committee adjourned to the 8th of April at 12 o'clock, when they propose to make a thorough examination of the building itself.

Burford's Panorama of Messina.—The additions so frequently made to this exhibition have rendered Mr. Burford's famous old panorama one of those standard sights of London which visitors are never tired of seeing, and it is deeply to be regretted that the one recently completed is destined to be the last of the long series produced wholly under the superintendence, and for the most part by the skilful hand, of that artist, who has just died at an advanced age. The view of Messina, to which we allude, is therefore invested with peculiar interest, independent of the political occurrences which are now transpiring there, and which render it perhaps the special point of European geography on which attention is now rivetted. It is not long since we noticed the large and fine picture of Rome then added to the attractions of this establishment; and this second Italian city is in every way worthy to rank by the side of that celebrated capital. Indeed, a more beautiful and picturesque scene it would be difficult to imagine. There is the long line of white houses glistening on the sea shore, the hills behind clad with verdure almost to their summits. There is, too, the vast and magnificent harbour, with the straits of Faro beyond, and in the distance are seen the mountains of Calabria. A prominent object in the foreground is the large and stately citadel, with the various palace-like buildings on the Marina. The luxuriance of the olive groves and orange trees increases greatly the richness of the scene, to which the deep blue expanse of the Mediterranean affords a delightful contrast, withal totally devoid of meretricious or overstrained effect. It has every appearance of truthful reality.

Exhibition of French and Flemish Pictures.—The eighth exhibition of works by artists of the French and Flemish schools, collected by Mr. Gambart, is now open at the Gallery, 120, Pall Mall. It consists of 137 pictures, and includes three works by Miss Rosa Bonheur, and one by Meissonier, entitled "In Confidence."

New Foreign Office.—The department of the Foreign Office is now removed to their temporary offices in Spring-gardens, and arrangements are pressed forward for pulling down the old buildings and erecting on the site and on the vacant ground adjoining, a new Foreign Office and a new Indian Office. Mr. Cowper, the Chief Commissioner, has also brought in a bill for purchasing houses in Duke-street, and for pulling down and rebuilding the State Paper Office. It is stated that the project for these buildings is to be entirely altered from what it was intended last year. By the plans then submitted to parliament, the Foreign Office occupied the whole of the site towards the park, and the Indian Office the other portion towards Parliament-street; but it appears now to be proposed to give the Indian Office half the site towards the park, and to re-arrange all the rest. The plans were submitted to Lord Palmerston and Sir Charles Wood, by the architect, Mr. G. G. Scott, on the 20th ult They are Italian in design, to harmonise with the adjoining buildings. The alterations at present contemplated are very extensive, including a new opening to the park, the widening of Downing-street, and the rebuilding of the Colonial Office and the offices of the Chancellor of the Exchequer, which at present close up the end of Downing-street.

Notre Dame.—The work of restoring the exterior of Notre Dame has been resumed, and the rose window over the southern entrance to the building is being repaired. The whole of the south portion of the building is to be restored according to the original design. This part of the church was originally commenced, as an inscription on the wall tells us, on the second day after the Ides of February, 1257, under the superintendence of Jean de Chelles, architect, during the reign of St. Louis, at which time Renaud de Corbeil was Archbishop of Paris.

Preserving Iron Pipes from Rust.—A workman of Paris has discovered a means of preserving water and gas pipes from rust, by covering them with a thick coating of clay.

Drinking Fountains.—On former occasions we have expressed our great regret that, with reference to their architectural design generally, the drinking fountains erected in various parts of London are really a disgrace to our thoroughfares. A similar opinion has recently been given by an eminent authority, Prof. Donaldson, and by several writers in the public press. It is therefore with much pleasure that we find some of our sculptors and architects are taking up the subject of fountains in a proper spirit. Among these are Mr. John Thomas, Mr. Darbyshire, and Mr. Tolmie. Mr. Tolmie has nearly completed a fountain to be fixed in Water-lane, Edmonton. The work rests on a Portland stone basement of rock-work, and rises to the height of 9 feet by a width of 4 ft. 9 in. It is semicircular headed, and a band of 1 foot in width incloses a deep recess, in which a dolphin in a vertical position, head downwards, is carved with great vigour. The dolphin spouts the water into a beautiful statuary marble shell, 30 inches in diameter. The water then falls to a lower level, where suitable troughs are placed for cattle. The surrounding band and circular head to which we have referred are embellished with cornucopiæ at top, bulrushes and other aquatic plants, and with various shells in bold relief, admirably grouped, and copied from nature with great fidelity.

The Superintending Architect, Metropolitan Board of Works.—On the 15th ult. Mr. Vulliamy was elected by the Board to fill this office, and he took his seat.

Lighting Steamers with Gas.—The Birkenhead Commissioners are trying the experiment of lighting the cabins of their river steamers with gas, a supply of which will be carried on board each steamer daily.

Railway Bridge over the Rhine.—The great railway bridge over the Rhine at Kehl being nearly completed, experiments to test its strength were made on it a few days since. First the two turning parts of the bridge were manœuvred, and were found to work admirably. That of the French side, which weighs not less than 350 tons, was moved with the greatest facility by eight men, then by four, and then only by two. Afterwards a train, consisting of five locomotives and their tenders, the locomotives alone weighing 175 tons, and the whole forming a weight of nearly 3½ tons per metre, passed over the line, and then remained stationary on the first part of the bridge on the French side; next, a locomotive and 15 waggons filled with stone, weighing about 1¾ ton per metre, was driven over, and was subsequently stationed for a time in the middle of the bridge; on the third place, the two trains passed over side by side, and were made to stand on different fixed parts of the structure; next, two other trains, each consisting of five locomotives, were also driven over the bridge side by side, and were made to remain together some time on the turning bridges and on other portions of the structure. The weight of these two trains was 350 tons, or nearly 7 tons per metre of the line covered. Lastly these trains were driven at full speed in contrary directions, passing each other on the bridge. Throughout the whole of these experimental trials the deflections of the bridge did not average more than from 8 to 10 millimetres, or between a third and two-fifths of an inch; the greatest deflection was equal to four-fifths of an inch, and in this case the part thus depressed rose again to its former level within a quarter of an inch. The results prove that the work has been well executed.

◆

COMPETITIONS.

Designs are required for a town hall and public offices at Kingston-upon-Hull, to be forwarded with plans, sections, and estimates to the town clerk, Hull, by May 31st. Premium £100. A block plan of site &c. may be had at town clerk's office, Hull.

Plans are invited for Embanking the river Thames within the metropolis, which will provide with the greatest efficiency and economy for the relief of the most crowded streets, tend to the improvement of the navigation, and afford an opportunity of making the low-level sewer without disturbing Fleet-street and the Strand. Plans to be sent to Mr. Henry Kingscote, secretary to the Thames Embankment Commission, 2, Victoria-street, S.W.

STATICS OF BRIDGES.

Erratum.

Page 64, col. 2, line 24 from bottom—" which is created in bc"; dele " which."

THE ARCHITECTURAL EXHIBITION.

Notwithstanding unfavourable weather, a numerous assemblage, including many of the leading members of the profession, and not a few ladies, were attracted to the Conduit-street Galleries on the evening of the 3rd of April, that being the occasion of the annual *conversazione*, previously to opening the Architectural Exhibition to the public on the following day. As usual, a portion of the evening was devoted to business proceedings, in reference to the doings of the past year and to the prospects of the present, with a brief statement (we can hardly say report) from the lips of the honorary treasurer, Mr. Ashpitel, who said, he might without vanity on the part of himself and colleagues, congratulate the meeting on the exhibition they saw around them, and on the position they now held in the eyes of the public. It was not many years ago, they must remember, when all their interests were very much scattered, when they had no general point of congregating, when there was nothing which could be fairly said to represent in this large city architectural interests—interests of such very great importance. He thought they might now congratulate themselves on being an Architectural Exhibition, recognised and very kindly patronised by the public. He thought their exhibition this year would be very satisfactory to all, and in his opinion, they had been going on from year to year increasing, and going on in importance and excellence. It was not for him to speak critically of the drawings on the walls, but he hoped they would all feel that the character of the exhibition had been increased in every way. Whatever their opinions might be as to styles and matters of that description, he thought they would see that architectural works were carried out with more thought and power than at any other time; there was less of an uncertain, flashy attempt to attract notice, and more of thought, in the architectural drawings presented before them that night. He wished to call attention to the exhibition of manufactures, which displayed an advance in skill and taste. About ten or eleven years ago, when the Architectural Exhibition was established, it would not have been possible to have drawn together a collection of manufactures of such exquisite skill and workmanship combined with taste and excellence. That showed that the labours of the committee of the Architectural Exhibition had been successful. In the catalogue of new materials there were several very interesting things exhibited, one of which was a very curious adaptation of what they commonly called concrete: there was a patent by which it would be made useful in ordinary matters at an extremely cheap rate. There were also imitations of marble on quite a new principle, which would enable them to add colour to decoration, and of a good and permanent character. There was another new feature in the exhibition, an improvement in the manufacture of embroidery; they all knew how important that was in buildings as a decoration, and the length of time and labour it cost to produce. It appeared that at Cologne a method had been invented by which embroidery could be simplified to a great degree, and yet produce a very great effect; through the kindness of Lady Mildred Hope there were some very fine specimens of that embroidery in the exhibition. He regretted that some few of their leading men—and it was a very few—had not contributed to the exhibition. There was no doubt it was a difficult thing for a man in the enjoyment of a large practice systematically to get up show-drawings on any occasion; but if some of their friends had gathered together some scraps and put them on a screen, it would have been to the exhibition a very great advantage. When a man did a thing heartily, it was enough; and he was sure they would all have regarded the will as the deed.

The chairman, Mr. James Bell, in the few observations he made to the company, remarked that he advocated the more general adoption of season tickets. The object of the exhibition was not to collect shillings at the door, but to spread and popularise a taste for architecture; and the more season tickets that were sold, the greater was the probability of that object being achieved. They wished to spread such a taste in architecture amongst the public generally that any architect who put up a bad building should not to do so again. He thought they had to thank the Royal Academy, for it had been the cause of the foundation of the exhibition. By confining architecture to a small room it had compelled architects to open an exhibition for themselves; and now, instead of having architectural drawings killed by some flashy picture, they had architectural drawings properly arranged together.

Our ideas of the exhibition generally will be better gathered from the perusal of our comments upon the principal works, than from any condensed expressions upon a subject admitting of so much variety to be considered, and in which there are so many interests involved. Suffice it to say therefore that the *coup d'œil* presented on the walls is much of the usual character, the eye being unarrested by any strikingly important picture; and that the "practical department" is as well filled as heretofore, and apparently with an advanced character of work. The models on the table, with the font and lectern in the centres of the rooms, and a very excellent piece of modern furniture in the end gallery, are features which present considerable novelty, and which will be examined with interest. It will be observed moreover that the number of provincial contributions is much increased, owing probably to an alteration in the regulations of the management, while the comparative dearth of competitions during the past twelvemonth has led to a very apparent diminution in productions of this class. Still the walls are well covered, presenting a more or less interesting series of 400 works.

The catalogue starts with "Design for the proposed rebuilding of a Grammar School" (1), one of the contributions of Mr. G. E. Street, which are, as might be expected, among the most attractive in the exhibition. Originality they are sure to display, and for the most part they are consonant with the true feelings of art. The next picture (2) is also of schools, now erecting at Moulsham, near Chelmsford, by Mr. F. Chancellor, and to which it affords a striking contrast. The powerful simplicity of the one greatly eclipses the barren plainness of the other, albeit we could point out many others in the rooms which are inferior even to this.

Associated with No. 3, which shows a "Bridge at Evesham, erected by Mr. J. Samuel, C.E.," we are glad to find the name of an architect, Mr. Robins. Too often in matters of this kind taste is wholly disregarded, and, for want of a few refined touches, which a well-educated architect can readily suggest, what might be a really ornamental as well as skilfully constructed work is left to present a cheerless, uninviting aspect. In the case before us not much has been aimed at, yet all is satisfactory. The bridge consists of three arches, segmental in form, and rusticated, and the whole is surmounted by a well-proportioned balustrade. In the same gallery is a large drawing of another bridge—"One of the cast-iron bridges erected in the public parks of New York," by Mr. Calvert Vaux (106). It is in a single span of 87 feet, the form being a very flat ellipse, and the roadway slightly raised in the centre. It is more noticeable for its boldness of conception than for refinement in its proportions or working out.

The "Sketches of the Class of Design of the Architectural Association" (4) are selected from the fortnightly productions of that useful class. The sketches before us scarcely equal in interest or quality some that we can recollect from the same source in former years, but the names of many who were then included in the "class" have now acquired an honourable distinction as individual exhibitors, and can date a large portion of their success to the instructive and inspiriting influence of the Association. Of the chosen sketches this year we single out for commendation those by Mr. W. T. Sams as, on the whole, the best, more especially his "Town Hall." Mr. C. H. Lewes' "Draper's shop front" is also commendable; but in the "Font" and "Bay window," by Mr. S. C. Rogers, ornamentation is allowed to roam in wild exuberance.

A bird's-eye view of the "Godolphin School," by Mr. A. W. Blomfield, forms the subject of (5), and would appear to be a well digested design, which is further exemplified by two photographs (335, 343), hung, strangely enough, in another room. But in our opinion, this gentleman's school—or "Mission House" as it is termed—in Bedfordbury (108), is greatly superior. The plan, two sections, and perspective view which are given, testify to the ability of the designer, both as to skill in planning and proportioning a not very manageable building.

Mr. J. Clayton's excellent drawing (7) recals to memory the much-to-be-deplored fact, that the fine old Town-hall of Hereford no longer exists. This building when perfect was one of the most remarkable specimens of timber architecture to be met with: it originally had three stories, the upper one finished with the very singular continental features of tourelles, or angle windows.

A restoration showing the building complete, made on the authority of old engravings, is given in the exhibitor's work, published in 1847, entitled 'The Ancient Timber Edifices of England.' Its site will now be occupied by a clock tower, for which some of the drawings sent in competition are in the collection we are now examining, and to which we shall in due course allot a few remarks. Meanwhile we may renew our protest against the Vandalism which has just been perpetrated in the demolition of the time-honoured structure, which was almost the only, as it was certainly the most curious, half-timbered building which the city could of late boast. Mr. Clayton's rejected proposal, here exhibited, was to thoroughly repair instead of remove the building, and introduce a town-clock, which is much needed, in a convenient position, and as an additional feature.

Mr. Appleton's "Design for Devon and Cornwall Bank, Exeter" (8), presents an ingenious alternative of a Classic or Gothic elevation, but beyond this ingenuity of adaptation there is little to commend; while, as a principle, it is one that should be deprecated. The "Chalet erecting in Lexden Park, near Colchester," by Mr. C. F. Hayward (9), is, as its title professes, based on the model of the Swiss half-timbered houses. It would seem to be well contrived and arranged, the plan and section being exhibited in connection with the elevation. We should pass over the next drawing (10), "St. James's Schools, Marylebone," by Messrs. Willson and Nicholls, as presenting nothing for remark, but for the hope that within the very unpretending shell which is here seen may be concealed something with more decidedly architectural claims, such as its authors are wont to produce.

A view of part of the interior of Lichfield Cathedral, by Mr. J. Drayton Wyatt, forms the subject of (11). It shows the part behind the altar-table, consisting of the Lady-chapel, and a portion of the choir, being the space proposed to be fitted up for the reading of a daily "Morning service," in conformity with the provisions of the cathedral statutes. (A view of this part of the cathedral was given in this Journal for January last.) This end of the cathedral is peculiarly rich in architectural effect, which is in some measure due to the loftiness of its apsidal termination, and owes much to the beautiful ancient stained glass with which the windows are filled. Two drawings of important public buildings come next under notice: the first (12), "The new Assembly Rooms and Music Hall, Newport, Monmouthshire, now erecting from the designs and under the superintendence of Mr. W. G. Habershon;" and the second (13), by Messrs. J. W. and W. Papworth, shows the "Entrance front to the Public Waiting Hall, Town Council Chamber, and Borough Magistrates' Court: part of the design for the Cambridge new Guildhall and Assembly Rooms, which obtained the second premium." Both of these are in the Classic style, the former decidedly Roman, and presenting a Corinthian order on a rusticated basement, the plan being an unbroken oblong; and the latter in a less *prononcé* Ionic school, and offering various novelties of design, not so much happy, we think, as original. In (15) we are glad to record a very successful Gothic drinking fountain, by Mr. F. Rogers, indeed one of the best that has come under our observation for some time, though it partially resembles, if we recollect aright, a fountain already exhibited by Mr. Burges. Its forms are agreeably blended, yet producing sufficient play of outline; it is, moreover, free from those incongruous fancies which so often mar the propriety of these useful modern contrivances. Some other good drawings of this class, by Mr. Appleton, will be found in (43). A large and showy "Bird's-eye view of the 'Great Malvern Estate Company's Land,' as laid out in 1860 by Mr. Joseph Clarke" (16), occupies a prominent place in this room, but has little intrinsically to demand attention. We prefer examining the adjoining quiet drawing by Mr. I'Anson of the "Church of Notre Dame at Dijon" (19), which is well deserving of study, and here clearly illustrated by plan, section, sketches, and details.

Mr. J. Drayton Wyatt's second picture is a view (from the south-west) of St. Lawrence's Church, Ludlow" (21), taken since its recent restoration, and showing, among other improvements, the three elaborate windows which now enrich the west end of this noble church. We are glad to see the increased study which is given to the façades of street architecture, and shall have occasion to refer to several drawings of such which are scattered on the exhibition walls; the first on our list however (24), showing a "House in Great Tower-street, City," by Mr. Parris, is not a good specimen. There is a difficulty, of course, in the treatment of the two or more upper stories of a building, when circumstances necessitate an open-looking shop below, but there is no reason for adding to the awkwardness by designing rusticated quoins where in reality it would be absurd to place them; nor can we praise the scanty balustrade which surmounts the whole. Mr. W. G. Habershon's "New Bank-buildings, and Lord Tredegar's Estate Offices, Newport, Monmouthshire" (26), though not open to such objections, is a very meagre design, quite unofficial in its aspect, and eclipsed in point of taste by the little picturesque Italian lodge which Mr. J. C. West exhibits in (27). The interior of St. Mark's, Venice, by the same gentleman (28), is not very satisfactory; but it is a difficult subject to handle.

Messrs. Walton and Robson are again in full force, with some of their sensibly-applied principles, especially in domestic work. Several houses in Folkestone, some of which are shown in (29), are illustrative of this, for, though plain, they are good-looking. Another drawing of similar merit by the same architects, is (92) a competition design for the North Riding Infirmary, at Middlesborough. Of the three competition drawings submitted by Mr. J. K. Colling for the Liverpool Cemetery, we prefer (31), that for the consecrated chapel, though perhaps it is a little too ambitious, and broken in outline. The materials proposed to be used were the red sandstone of the district, with dressings of Stourton stone. Mr. Raphael Brandon, who, like Mr. Colling, is well practised in Gothic, sends, in (33), a view of the steeple of his new church in Windmill-street, London, as it will appear over the houses in Tichborne-street. It appears to have been the author's aim, in determining its design, to give it an individual character, which shall isolate it from others in its immediate neighbourhood, as unmistakeably as does that of Margaret-street in another quarter. The type is evidently continental, but without being directly imitated, so far as we are aware, from any one example, and it promises to be a successful novelty. Mr. Pearson's new "Schools at Vauxhall" (34), also display considerable originality, the ideas being well worked out.

By Mr. Brodrick's prize design for the Leeds Mechanics' Institution (36) we are reminded of the circumstances of the late competition. There is a grandeur of effect about the mass of the elevations, which suffers by the tameness of the details. By far the best feature is the principal entrance, which is sufficiently important in magnitude, and beautifully detailed. The most faulty conceptions are the puny domes, a feature which few modern architects, excepting the late Mr. Wilkins in his University College, have rendered even passably tolerable, and he, as we know, was not always as fortunate. We are sorry we cannot speak so favourably of (45) Mr. Brodrick's "Design for the Corn Exchange, Leeds," or of his two competition drawings (102, 109) for the new church at Scarborough. Of the two drawings forwarded by Mr. T. Harris (39, 392) we know not which is the worst. They are professedly "*Victorian*" in style, we imagine, (according to the author's ideas,) but any thing so utterly jumbling we do not remember ever to have seen before. There is variety enough truly, and unceasing novelty, but it is of the very worst kind, devoid of taste, and evincing an utter ignorance of the principles of architectural composition.

The monotony of building and landscape pictures is here and there relieved by other branches of art, and prominently so by the glowing cartoons of stained glass, in which the names of Messrs. Heaton and Butler figure as the chief exhibitors, they having no less than eight contributions, while Messrs. O'Connor, Lavers and Barraud, Clayton and Bell, may also be mentioned in the same list. In this department we recognise a gradual advancement in the right direction, though much remains to be accomplished, yet the several artists in this material appear to be striving to the utmost to bring it to perfection. In carving and sculpture, too, considered as accessories to architecture, there has been for some time a satisfactory progression, as the numerous photographs around, taken from executed works by Boulton, Earp, Phyffers, Swales, and others, will clearly show. We may especially point to the "Reredos for Howsham new church" (46), as a specimen of the purest taste and delicacy of finish, though much of this is attributable to the architect's own ability and superintending skill. We beg to refer our readers to the interior view of this beautiful church, given as one of our illustrations this month.

The Hon. Sec. to the Exhibition, Mr. Edmeston, sends several drawings and photographs, chiefly illustrative of domestic buildings executed or in progress under his direction, and they have a claim to notice as showing what may be achieved by a judicious adaptation of simple forms in ordinary materials. The photograph of the "Porch to a house at Norwood" (42) is, if we mistake not, the same design as appeared as a *drawing* in last year's exhibition. Near these are two small photographs, showing (50) a new "Church at Whitwell, Yorkshire," and the "Pulpit" in the restored church of Stone, Kent (51), both by Mr. G. E. Street. Some beautiful photographs also of "Minley Manor-house, near Farnborough" (59), recently erected by Mr. Clutton, will not fail to attract notice. The effect of the building is well explained by views from several points, assisted by a ground plan, and will elicit approval from the careful study which it is evident has been given throughout, even to the minutiæ of detail, though the advisableness of reproducing so close an embodiment of the French château, with its inordinately high-pitched roofs, is open to question. While enumerating photographs, we may point to that of an exterior of Mr. Street's church at Howsham (61), which appeared as our lithographed illustration in the March number of this Journal; also to a small collection of executed works by Mr. G. R. Clarke (62), and a highly interesting series by Mr. C. Gray (134), under the title of a "Professional Census—1851 to 1861," consisting partly of executed works and partly of designs, many of which have previously found a place on the exhibition walls in the shape of large tinted drawings.

The name of Mr. Owen Jones is a guarantee for the excellence of whatever emanates from him, especially where colour is concerned. Thus his "Designs for Illuminations to the 'Paradise and Peri'" (67, 68, 79, 80), and for the "binding" of the same book (69), will be examined with advantage. The fanciful play of forms is indeed no less skilful than is the selection of the tints, which serve so materially to heighten the brilliancy of the whole. We shall have occasion, when noticing the Inventions, to refer to "Marmolite," a drawing showing the application of which may be seen in (71). The large block of building described as the "West Midland Hotel, now being erected at Great Malvern for the Great Malvern Hotel Company, from the designs of Mr. E. W. Elmslie" (73), presents but few claims to consideration in respect to its details, which seem to be anything but suitable in a building of such pretensions. The elliptical heads of the windows and other openings are in England unusual, and they strike us as being anything but satisfactory, while their constant repetition gives an air of tediousness, which could have been easily obviated by occasional variety in the details. Mr. W. J Green's "Competition designs for the Houses of Parliament, at Ottawa, Canada" (74), is exhibited rather late in the day, since on long bygone occasions the successful designs and those of other competitors were submitted to critical examination. In the case before us the author has adopted the Italian style, with which he is thoroughly conversant. An important feature is the octostyle Corinthian portico, the pediment being enriched with sculpture. Taken as a whole, however, the proportions are not well balanced, and some of the minor parts would admit, in execution, of being reconsidered with advantage. There is considerable boldness in Mr. Tarring's "Congregational church about to be erected at Bayswater" (75), though we cannot altogether sanction the two cupolas which flank the entrance. except on the principle of uniformity. As regards design they have great merit.

In (83) we have another result of the "Leeds Institution" competition, being the three elevations sent in by Mr. De Ville. They are purely Italian, and cleverly designed. The "Middle School and Lodge, about to be erected at Handsworth" (84), by Mr. Bidlake, is of more than average excellence: it is of red brick, banded, and into its details as well as its masses there is infused no little picturesqueness of treatment. The "London street front," now nearly completed, by Mr. Ashpitel (88), we believe may be seen somewhere in the neighbourhood of Cripplegate.

Two designs must now be alluded to which have been called forth by the proposal to cover the area of the Royal Exchange with a glass roof, as recently advertised, and which we presume will shortly be carried into effect, though the question is not definitely settled whether the covering shall spring at the upper or the lower level of the quadrangle. Architecturally considered there can be no hesitation whatever that the former is the only scheme which ought to be seriously entertained, and practically, too, we foresee considerable difficulties should the alternative be decided on, as seems to be the prevailing wish among those in authority, but whom we cannot designate men of taste. The architect to the building, whose opinion should have its due weight, has with others of his profession strongly protested against this latter idea; while various scientific men have clearly shown that the objections raised in certain quarters to the former proposition may be readily disposed of. It may be hoped therefore that good sense and deference to public feeling may ultimately prevail over narrow-minded and selfish prejudices; and that if the area is to be covered at all, it will be altogether above and independent of the existing architectural features. Mr. Stapelton, in his design (93) suggests a light arched form to span the whole, and to have two domes in its length, to break the flatness and monotony of the crown. It is, moreover, so adjusted as to fit to either the upper or lower stage of the building, without any pretension whatever to architectural additions. In this respect it differs from the proposal of Mr. De Ville (97), which is to have a low-pitched roof of glass, with trusses and tie-beams at the ordinary intervals, but the whole of the construction to be cased; and the plain surfaces (which by this method would be considerable) to be coloured, as also the coffered soffits along the margin. This design, which is very artistically rendered, reminds one of some of the modern Bavarian structures, and is applicable to the upper level only. Mr. E. W. Godwin's "Design for Long Ashton School" (98) is good in outline, and has various recommendatory features; the walls are specified to be built of native stone and Bath stone, the roof covered with plain tiles. In the "Second selected design for the Faversham Almshouses" (99), Messrs. Newman and Billing exhibit a rather ambitious scheme, which, without being decidedly faulty, or even common place in design, has not much to recommend it when closely scrutinised. The arcaded lean-to which extends for the most part along the front is particularly unsightly in form, and starved in its construction. We notice several ugly skylights in its roof, which might surely have been better managed. Two excellent photographs of a Roman Catholic chapel and mortuary cross in Kensal-green Cemetery (100), by Messrs. Willson and Nicholl, are deserving of attention. The chapel was illustrated in our Journal for September 1859: the cross is designed in the best taste, and judiciously enriched by carving. Mr. Pritchett, in his "Interior of High Wych Church, Herts" (104), shows a very plain church, plainly treated. The arcade between the nave and aisles has, we observe, one square soffit only through the whole thickness of the wall, and without a label. The exterior is shown in (119).

The "London-bridge Railways Terminus Hotel, now being erected" (110) by Mr. Currey, is one of the happiest efforts in point of design which the gallery contains. It is Italian in style, and abounds in studied and well-proportioned details. Considerable taste is also displayed in (111) "Design as first proposed—Coffee room erected in Chancery-lane, for Mr. Button," by Mr. F. H. Fowler, but much would depend upon the coloured decorations being carried out in their integrity, as here shown, otherwise all would sink into comparative insignificance. Mr. Goldie is, as usual, a liberal exhibitor, sending eight drawings. In the first we come to (115), "East and west views of new church of St. Bridget, Ballymote, Sligo, Ireland," the author would appear to have borrowed an idea or two from other modern works; but we speak under correction The remainder of his drawings will be noticed in due course. In the "Design for Congregational Church at Lower Clapton" (116), Mr. Barber has ably combated the difficulty of so managing a continuous line of building as to secure variety without sacrificing harmony. We welcome with pleasure the artistic yet thoroughly architectural drawings contributed in (122), by the well-known Mr. J. H. Parker. They illustrate the "Eglise St. Pierre, Touques, and other buildings in Normandy." Another of the Clapton Chapel designs, by Messrs. Lander and Bedells, occurs in (123), and is noticeable mainly for its succession of gabled windows to the aisles, a fancy which seems now all the rage among certain architects. In the two "Staircases at Amesbury Abbey, Wilts," shown by Mr. J. J. Cole in (124), we have open corridors, architecturally treated, round a quadrangular area—an effective as well as convenient arrangement, where space will allow of its adoption.

Mr. E. W. Godwin has so frequently shown his power of thinking and designing for himself, that we can the less excuse so unmistakeable a copy of the Oxford Museum as he has been guilty of in his competition drawings for the Clifton College (125), to which, nevertheless, were awarded the second premium. Their leading outlines are marvellously alike, both in plan and perspective, only that a packsaddle roof is substituted on the central tower for the hipped form of its prototype, and that the wings are differently managed. (129), A house now erecting at Shere-heath, Surrey, by Mr. T. C. Clarke, is tolerably good-looking, especially in the subsidiary parts of the design. (132), The "Diocesan Training College, Winchester," now erecting by Mr. Colson, does not strike us as being worthy of the object or of the architect. The contract is £7500, and the walling is to be of Swanage stone, with Box-ground stone dressings. Certain drawings submitted in competition for the Liverpool Cemetery Chapels have already come under our notice; two others (135, 136), by Mr. Goldie, may here be mentioned. The former of these is disfigured by the shape of the bell turret, which in the other drawing is differently managed, and with a better result.

(To be concluded in our next.)

The committee have arranged for the delivery of art-lectures, on successive Tuesday evenings, during the exhibition season, as heretofore. One of these, on "Architecture in London," by Mr. Beresford Hope, was announced for last evening, April 30th, those yet to be delivered, with the names of the respective lecturers, are as follows:—

May 7th—Sir C. Wren and his Times. By Mr. Robert Kerr.
„ 14th—Romanesque Architecture. By Mr. Edward A. Freeman.
„ 21st—The Revival of Styles. By Rev. J. L. Petit.
„ 28th—Church Architecture of the Nineteenth Century. By Mr. R. P. Pullan.
June 4th—On the Restoration of Ancient Buildings. By Mr. George E. Street.

Season tickets, at half-a-crown each, will admit the proprietor to all these lectures, as well as to the exhibition at any time, and they are consequently, as might be expected, in large demand. The exhibition will remain open till the 30th of June.

◆

SUSPENSION GIRDER BRIDGES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—The subject of suspended girder bridges is evidently receiving that thorough investigation which is due to so important a subject. Will you allow me to say a word upon the valuable paper at pages 317 and 352 of last year's volume of your Journal, and on the suggestion of Mr. Köpcke at page 6 of the present volume. In the first of these it is soundly argued that a suspended girder should be strong enough to sustain theoretically—

1. A load of half the weight per foot run of the rolling load, distributed upon half of its length, beginning from either end: that half of the girder being considered to receive no assistance from its connection with the other half.

2. That it should be in practice of uniform strength throughout.

And again, as to the chains, I gather from the fact of their being recommended to be strained, so as to give the girder initial camber, that

3. The chains should be able to carry the whole weight of themselves, girder, and load.

Then the writer of the paper quietly avoids the subject of temperature. A consideration of this, in as close detail as the former subject of load, would have made his investigation complete.

I must protest against the avoidance of this subject, simple as it may be; in my view, it is the great difficulty. Temperature has no influence on the deflection of the girder—it has a great influence on that of the chains; and it is necessary, in a complete investigation, to give at least a rough calculation of the condition of strain upon the various parts of the bridge, at the two extremes of possible heat and cold. In treating of a hanging girder, I have estimated that the ironwork of the bridge required increasing above $\frac{1}{6}$ (more accurately $\frac{2}{11}$) of its weight, to meet the effects of temperature.

Mr. Köpcke has introduced a notion of a hanging girder with a hinge at its centre. This naturally suggests a suspended girder (or, rather, two suspended girders), with a tooth, flange, or hinge at the centre of the span, so as to enable them to fall or rise as the chain expands or contracts with varying temperature. A practical investigation of all these bridges is vastly needed, but none can be safe which neglects temperature.—I am, &c.,

JOHN H. LATHAM.

Nellore, Madras, 15th February, 1861.

[Mr. Latham rightly construes our meaning to be that the chains should be able to carry the whole weight, of themselves, girder, and load: the task of the suspended girder being simply and solely the distribution of the load; and that of the chains, the actual support of the load thus distributed.

We have considered the rigidity of the girder as uniform throughout, and in practice it should be so for the greater part of the span. At the same time, a little economy of material might be safely effected in the quarter-span next either pier, by somewhat lightening the section of the girder (from a point distant from the centre 0·27*s*) towards the end. And in the case of a single span of large dimensions, some further saving might be found practicable towards the centre of the girder, where the strain is not so severe as at the quarter-span.

We found that, apart from the stretching of the chains, and for a bridge of a single span only, the suspended girder should be strong enough to carry a load of half the weight per foot run of the rolling load, distributed upon half its length, beginning from either end (as Mr. Latham correctly puts it). And we proceeded on the implicit understanding that at the point of contrary flexure the loaded portion of the girder receives no accession of transverse strength from its continuity with the other portion, but only a certain amount of vertical support.

But here it is of importance to bear in mind that to the strength of the girder, as computed on the foregoing principle, an addition has to be made, to meet the further strain resulting from the stretching of the chains as the load comes on the bridge. An additional contingent strain has also to be provided for, dependent on the thermometric expansion of the chains. This latter point is of very great importance, and it has already received some attention from us. In the article to which our correspondent refers (vol. xxiii. p. 354, col. 2), we considered that the depth of the girders should not exceed from one-third to one-half the rise of the chains, in order that they might be sufficiently flexible to follow their motion, and never cease to be truly suspended girders. And in p. 353, col. 2, we gave a formula for the degree of fall caused by the lengthening of the chains, which we stated to be as applicable to the effects of temperature as to those of tension.

We are, however, glad that our correspondent presses home this question, since, although we think the passage to which we have referred puts the answer fairly within reach of our readers, the matter certainly deserves a more detailed consideration than we then found space for.

The girder will be most severely taxed when, in addition to the theoretical maximum strain, and the effect of the stretching of the chains, it is subjected to a further deflection owing to the expansion of the chains by heat.

Unless the suspended girder is fixed at an extreme winter temperature, the chains will of course occasionally rise as well as fall. But it is with the degree of fall that we are mainly concerned, since it is the fall that adds to the effect (in itself considerable) of the settlement of the chains under tension.

Suppose the temperature at which the bridge was fixed, or to which it was ultimately adjusted, to be such that the expansion due to extreme summer heat would be at the rate $1:1+e_2$. And let the elastic strength of the chains be such that the greatest rolling load will cause them to stretch at the rate $1:1+e_1$. Also, let $s=$ span, $v=$ rise of chains, and $m=$ rate per foot forward of greatest rolling load. And let the girder, as first calculated for the theoretic strain $=\frac{ms^2}{64}$, be of such rigidity that (without the support of the chains) a rolling load at the rate $\frac{m}{8}$ covering the entire span would deflect it D; D not exceeding one-fourth of its ultimate deflection.

The greatest rolling load would cause a settlement in the chains

$$=\frac{25\,e_1}{32}\left(\frac{s^2}{4v}+\frac{4v}{3}\right)=d;$$

and the greatest rolling load on half the bridge would cause a settlement $=\frac{1}{2}d$.

The greatest summer expansion would cause a settlement or fall

$$=\frac{25e_2}{32}\left(\frac{s^2}{4v}+\frac{4v}{3}\right)=\delta.$$

D, d, and δ are given in terms of a foot.

The result of the settlements $\frac{d}{2}$ and δ combined will be to throw on the girder an added strain at the quarter-span

$$= \frac{3d + 6\delta}{8D} \times \frac{ms^2}{64}.$$

To provide properly for this strain, the flanges of the girder should be made heavier, so that the rolling load at the rate $\frac{m}{8}$ should deflect it not D, but only $D - \frac{3}{8}d - \frac{3}{4}\delta$. That is to say, the sectional area of the flanges must be first calculated for the strain $\frac{m\,s^2}{64}$, and then increased in the ratio of $1 : 1 + \frac{3d + 6\delta}{8D - 3d - 6\delta}$.

A forced camber given to the girder, or (which comes to the same thing) its adjustment to extreme summer temperature, would, by reducing the actual strain thrown on the girder by the settlement of the chains, allow a considerable abatement in the weight of the flanges. Thus, if there were a forced camber $= k$, the proportion in which the area of the flanges should be increased would become reduced to $1 : 1 + \frac{3d + 6\delta - 6k}{8D - 3d - 6\delta + 6k}$.

If, then, the bridge is adjusted to a mean temperature, so that the extreme summer fall (δ) is half the total variation between summer and winter, and if a camber (k) be added $= \frac{d}{2}$, the area of the flanges will be found as follows:—

1. Take the area ($=$A) calculated for the proposed depth of girder for a strain $= \frac{m\,s^2}{64}$, or it will now be more accurate to say, for a strain $= 0{\cdot}132 \times \frac{ms^2}{8}$ (See page 35 *ante.*)

2. Increase A in the ratio $1 : 1 + \frac{3\delta}{4D - 3\delta}$. Thus, if $D = 0{\cdot}83$ foot ($=$10 inches), and $\delta = 0{\cdot}17$ foot ($=$2 inches), the increase will be at the rate of $1 : 1 + \frac{51}{332 - 51}$, or about 18 per cent.

The preceding applies only to bridges of one span. Were there more spans than one, the rate of increase would be

$$1 : 1 + \frac{\delta}{D_2 - \delta}$$

In this case D_2 is the deflection of the girder, if unsupported, under a load equal to half the greatest rolling load, distributed over the entire span; and A must be calculated for a strain $= \frac{ms^2}{16}$.

If $\delta = 0{\cdot}17$ as before, and $D_2 = 0{\cdot}83$, the increase of area to provide for thermometric settlement will now amount to 25 per cent.

The formula we have hitherto employed to find d or δ in terms of e, gives the effect of the elongation of the chain alone. There will be two other causes at work which we have not yet spoken of, and each of which in a subordinate degree affects the deflection.

The first of these causes is the lengthening of the suspension rods (more especially of the long ones), whether from heat or tension. As the girder will not admit of an abrupt depression near the pier, the result will be that the upper portions of the chain will rise, the curve becoming flatter, while a slack will be thrown towards the centre of the chain, causing it to droop. The girder on the whole will drop, in a curve not very different in form from its natural curve of deflection under an equally distributed load.

The second cause of altered deflection is found in the compression of the towers, which tends, of course, to increase, and the summer expansion, which tends to diminish, any settlement. With iron towers the latter effect would certainly become appreciable; and also the former, unless there were a liberal allowance of sectional area. But at the time when the bridge was most severely taxed from summer expansion and the weight of the rolling load combined, the compression and expansion in the piers would so far neutralise one another that the resulting displacement either way might well be neglected.

A word has yet to be added as to the first cause of subordinate disturbance above mentioned, namely, the lengthening of the rods. The effect of the lengthening of the chain is, as we have elsewhere said, a deflection $d = \frac{25e}{32}\left(\frac{s^2}{4v} + \frac{4v}{3}\right)$. This expression, resolved into two terms, becomes

$$d = \frac{25e}{128}\frac{s^2}{v} + \frac{25}{24}\,e\,v.$$

Of these two terms the second is considerably the smaller, its value varying in practice between 8 per cent. and 4 per cent. of the entire settlement d. Now the effect of the lengthening of the rods is comparable with this small second term. It is therefore one which would be amply met by 2 or 3 per cent. more metal in the flanges of the girder.

A last consideration (although by no means the least), is the slack thrown in the chains by the stretching or expansion of the stay-chains. As far as this cause is allowed to operate, a further addition of metal in the girder is demanded, to calculate which the length and position of the stay-chains must be known. But we know of no expedient so good as that invented (and we believe patented) by Mr. Ordish. A weight is so hung from a point in the stay-chain between the tower and the anchorage that the stay is always kept taut, and its expansion or contraction consequently does not affect the main chain.—Ed.]

◆

EXHIBITION OF INVENTIONS AT THE SOCIETY OF ARTS.

The annual exhibition of inventions in the rooms of the Society of Arts affords inventors good opportunity of making known the products of their inventive faculties. It is now fourteen years since the society commenced these exhibitions, which may be regarded as the precursors of the Great International Exhibitions; and it is to be regretted that they do not attract more public attention. In a country like this, which depends for its prosperity mainly on improvements in the manufacturing arts, it might be supposed that great interest would be excited to witness the progress that had been made during each year; but comparatively few of the multitudes who rush to other sights, turn to look at the display of ingenuity, open gratuitously every spring, in John-street, Adelphi. This apparent indifference to the progress of mechanical arts may be in a great measure accounted for by the want of proper accommodation in the society's house for such an exhibition, without sacrificing to that object the room in which they hold their weekly meetings. The dimly-lighted chamber in which the articles are deposited is not a fitting place either for their reception nor for the reception of the company who may want to see them; and the knowledge of the unfitness of the exhibition-room, and of its unattractiveness, prevents the greater number of inventors from becoming exhibitors. Out of upwards of 3000 inventions patented during the last year, not one-tenth part are represented in the exhibition of inventions by the Society of Arts. The forthcoming International Exhibition may have also tended to deter many from anticipating their appearance on that occasion. Notwithstanding these depressing influences, the exhibition this year contains many things deserving attention.

The first objects that present themselves are models of boilers, furnaces, furnace-bars, and other appliances for the generation and regulation of steam. No. 3, a smokeless furnace, patented by Mr. W. Yates, possesses considerable merit, though, if we mistake not, the principle on which it depends has been previously claimed. The fuel is supplied above the mouth of the furnace from a hopper, with a bottom attached to a transverse shaft, which may be moved by hand to open a passage for the fuel. Several of the central fire-bars are connected together by transverse bearers, the outer ends of which are supported on a rocking quadrant. By this arrangement, when the fuel descends from the hopper it is carried forward into the fire-chamber by the horizontal movement of the central fire-bars. The door is kept closed during the ordinary working of the furnace, but there is a hole in it through which the condition of the fire may be occasionally observed, and the stoker's tools applied, if necessary. The accompanying woodcut represents a sectional elevation of the furnace, in which b shows the transverse shaft at the bottom on one side as would be drawn up on the other, and the weight would remain stationary. But as one grooved circumference in the upper block is of smaller diameter than the other, when the pulley is turned the chain is raised on one side more than it is lowered on the other, in proportion to the difference in diameters of the two grooves, and the weight is raised to that extent. Were the force applied to the chain that is geared round the smaller groove, instead of the weight being raised, it would descend. The notches on the chain-wheel prevent the weight from running down when the difference in the diameters does not exceed that in the block exhibited; but were the diameter of one to be much greater than that of the other, the additional leverage would overcome the resistance, and the weight would in that case run down. By a pulley-block of this kind it is said that a man may readily raise a ton weight, and without any accessory mechanism the weight is sustained in the position to which it is lifted.

Some large specimens of the new metal, aluminium, and of its alloys with copper (No. 88), are exhibited by Messrs. Bell Brothers, of Newcastle-upon-Tyne, who are said to produce it at such an economic rate as to render it applicable for many manufactures, and for some parts of machinery, with great advantage. The pure metal resembles platinum, and in its resistance to the action of some of the most powerful acids it is also like that metal, but its other properties are very different. The specific gravity of aluminium is not one-eighth part that of platinum, and it is four times less than that of silver; it is therefore the lightest of all known metals, excepting the bases of the earths and alkalies. It is capable of being forged, rolled, and drawn into wire, and melts at a temperature a little above that of zinc. The chemical properties of aluminium are very peculiar. Sulphuric and nitric acids have no effect on it, nor have caustic alkalies; but muriatic acid dissolves it readily, and alkaline solutions also act on it with energy. The alloys of aluminium with copper, or aluminium bronzes as they are called, possess a degree of tenacity and hardness equal to that of steel. A bronze composed of 10 parts of aluminium and 90 parts of copper looks like gold, and is said to take as fine a polish as steel. It is stated, in proof of the hardness of this bronze, that a groove for the guide blocks of a locomotive engine, made of that alloy, exhibited no appearance of wear after six months' use; and that it was tried for the journals of the front wheel of a locomotive with very good effect; its great malleability, combined with its hardness and tenacity, rendering it well adapted for that purpose. Aluminium is coming into general use in small Birmingham manufactures, and its great strength and hardness, and its nonliability to corrode, seem to render it a desirable substitute for steel in many parts of machinery, if it can be produced at a cheap rate.

An apparatus for deep-sea sounding (No. 95), contrived by Dr. Wallich, will be very serviceable in surveying the bottom of the sea, previous to laying down telegraph cables. Two hemispherical cups are kept open by a heavy weight, which, on touching the bottom, falls off, and the cups are firmly closed by a strong elastic ring. Specimens of the mud, or other loose matters at the bottom, can thus be effectually secured and brought to the surface.

In the section of building and domestic appliances, there is a model of a method of sheet-roofing with slate, invented by the Rev. T. Martin; a self-acting cleansing and purifying apparatus; contrivances for rendering window sashes air-tight; new sash frames; relievo covering for walls and ceilings; a heat regulator; a corrugated chimney-top, and other inventions: none of which, however, so far as can be ascertained in the gloom in which they are obscured, possess much novelty, or promise practical utility.

SUBWAY, COVENT GARDEN APPROACH, LONDON.

(*With an Engraving.*)

The accompanying plate exhibits plan and sections of the subway recently constructed by the Metropolitan Board of Works, under the new street extending from Cranbourne-street to King-street, and forming a much-improved approach, from the west, to Covent-garden Market.

The subway was designed by Mr. Bazalgette, the engineer, in conjunction with Mr. Marrable, late architect to the board, for the purpose of receiving the pipes and mains for gas and water, laid in such a manner that easy access could be had to them at all times without disturbing the surface or roadway; and their object was to accomplish this by an arrangement simple in form, and at the least possible expense. The length of the subway executed is 374 feet. The total width of the street in the clear is 50 feet. The arrangement consists chiefly of a central continuous passage or subway, extending the whole length of the new street, of sufficient dimensions (12 feet by 6 feet 6 inches) to admit of the deposit of any requisite number of gas and water mains, and telegraph wires, with ample working room for alterations, additions, or repairs. Under the centre of this passage runs the sewer, to which means of access by man-holes are provided at convenient distances, as also ventilating shafts, gullies, &c. Side-arched passages communicating with the central way are constructed between every two houses, in which the service-pipes are carried from the mains into the open areas in front of the houses, and open channels are left in the footings of the walls dividing the house-vaults through which the service-pipes are carried without any interference with the structural arrangement; and these channels, although of small dimensions (4½ inches by 3 inches), being always left open will act as drains for the admission of air from the open areas into the central passage, which in conjunction with ventilating shafts at convenient distances into the roadway, will secure an ample current of air for all the purposes of ventilation. An entrance to the main passage is provided in Rose-street, similar to the ordinary side-entrances, but of such dimensions as to allow of the ready admission of the main pipes for gas and water, which, as all the service-pipes are laid in sunken channels, can be readily carried to any required point on a small truck kept in the subway for the purpose. Provisions have also been made for the hydrants or fire-plugs, and for the service of the street lamps.

Estimates have been prepared by the Board of Works, showing the exact cost of the private vaults of the houses, the paving of the foot and road ways, together with the cost of the ordinary sewer, including digging side-entrances, ventilating shafts, gullies, &c.; by which it appears that the extra cost of constructing the subway, as executed, does not exceed £2 per foot run, or, divided between the houses on the two sides of the street, about £1 per foot frontage on each house, which, together with the cost of the vaults, sewers, and road, might be charged at once on those taking up the ground-rents, or be added as an annual charge in addition to the ground-rent, and which, of course, would form a part of the annual rental, to be sold when the board should think fit to realise the ground-rents. Mr. Thirst, of Chelsea, was the contractor; the amount of contract was £4391.

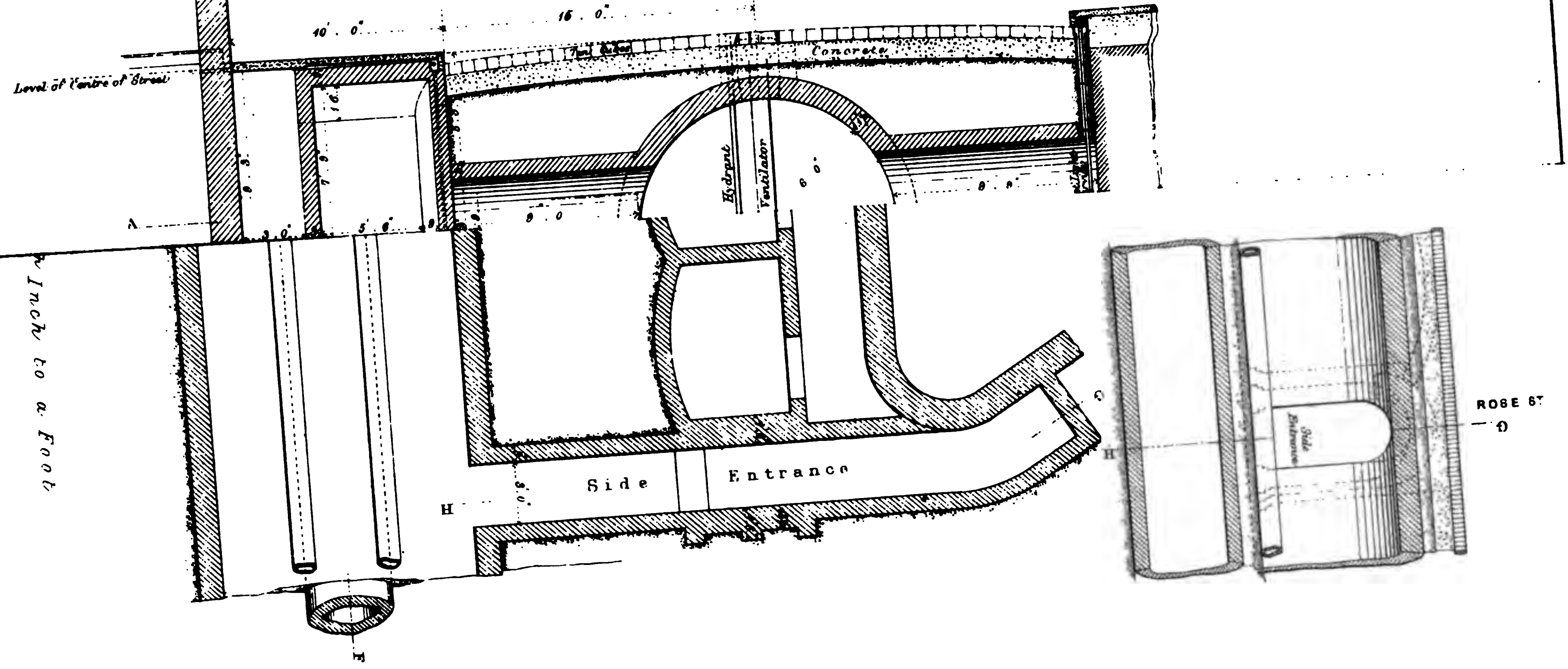
Original Estimate of Subway, Sewer, Cellars, Foot and Carriage-way Paving, at per foot run of frontage.

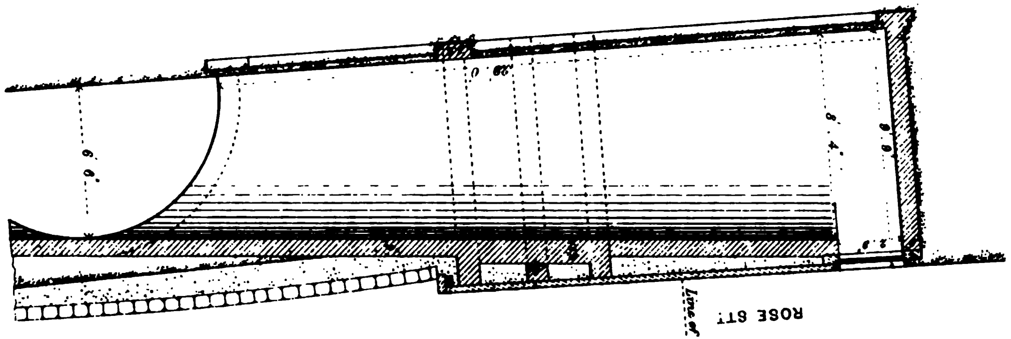
	s.	£.	s.	d.
Sewer—				
Excavations, carting away, &c. 0·42 cubic yd. at 2*s.* 6*d.*	1·05			
Brickwork, 4·66 cubic feet, at 11*d.*	4·27			
Junction blocks, 9-inch pipe	0·06			
Sub-way—	——	0	5	5
Excavations, &c., 2·273 cubic yards, at 2*s.* 6*d.* ...	5·68			
(Central passage) brickwork, 13·16 cubic feet at 11*d.* ...	12·06			
Excavation, &c., 0·306 cubic yard, at 2*s.* 6*d.*	0·76			
(Side passage) brickwork, 2·14 cubic feet, at 11*d.* ...	1·96			
Cellars—	——	1	0	5
Excavations, &c., 3·535 cubic yards, at 2*s.* 6*d.* ...	8·83			
Brickwork, 22·930 cubic feet, at 11*d.*	21·02			
Pitching (brick on edge), 0·525 square yard, at 3*s.* 6*d.* ...	1·84			
Paving, area 2½ flag, 0·324 square yard, at 4*s.* 10*d.* ...	1·56			
Forming of street—	——	1	13	3
Excavations, 1·02 cubic yard, at 2*s.* 6*d.*	2·55			
Concrete, 0·83 cubic yard, at 6*s.*	4·99			
7-inch granite cubes, 1·66 square yard, at 16*s.*	26·56			
Kerb, 0·25 cubic foot, at 5*s.*	1·25			
2½ paving, 0·665 square yard, at 4*s.* 10*d.*	3·21			
3-inch paving, 0·103 square yard, at 5*s.* 7*d.*	0·57			
	——	1	19	2
Add proportion for side entrance, ventilators, &c. per foot run		0	1	6
Total cost per foot run of frontage		£4	19	9

The length of the frontage of the houses is about 880 feet.

Since this estimate was made the board have decided upon charging the cost of the cellars only to the purchasers of the plots of land, so that the excavation for and formation of the subway itself for a length of 374 feet has to be deducted from the above estimate, and forms an outlay by the board on behalf of the public.

Cross Section on C.D.





Section at G.H.

Inch to a Foot

JR Jobb

ON CONSISTENCY OF STYLE IN DESIGN, AS EXEMPLIFIED IN THE WORKS OF THE QUATROCENTO PERIOD.*

By Sydney Smirke, R.A.

In a former lecture I called your attention to a period in the progress of our art which must ever be of great interest and value,†—I mean the Quatrocento period, for it was then that the foundation was laid of a new epoch or style of art, founded it is true on the admired examples of antiquity, but adapted and reshaped to meet the new wants and altered habits of modern life. On the occasion to which I refer my retrospect reached back to the earliest germination of the Renaissance. We found that even so far back as the middle of the fourteenth century there was a manifest dawning of the coming change; and that by the middle of the following century the revolution had been completely effected. I recommended to your special attention and study the beautiful and in many respects original style of design which the best masters of that period practised; the style, in short, which we observe in the works of the Lombardi at Venice, of Alberti at Rimini, and elsewhere, and of some few other eminent artists who led the way in that new school.

But it is not to be denied that that style is characterised—perhaps I ought to admit, disfigured—by certain archaisms and conventionalisms similar to those which are observable in the sculpture and painting of the same transitional period. In fact, throughout the fifteenth century a savour of Mediæval art had remained: works of great purity and beauty would often present some quaint conceit, a reminiscence of the past analogous to that which still tinctured the elder schools of the other branches of art. This no doubt was occasioned by an unwillingness, not uncommon, to depart from a trodden path, and to that reverence and prepossession with which it is natural to regard the works of our forefathers. Nor is this habit peculiar to architecture alone. The other arts were, *pari passu*, partaking of the same innovating spirit. Old habits and partialities had to be overcome, old barriers broken down, both in painting and sculpture. There were those who still persisted in representing human figures standing on the extremities of their toes, and who would not learn to represent a horse walking as alone a horse can by any possibility walk. Vasari dwells with some *naiveté* on the impotent dismay with which the men of the old Gothic school beheld their long-cherished traditional delineations of natural objects set at nought, and their conventionalisms disregarded and wholly displaced in popular estimation.

The new manner of design in the three sister arts appears to have become completely matured at the close of the fifteenth century—not, it is true, in Europe generally, but in Italy, which was then immeasurably in advance of other countries in æsthetic cultivation. A particular interest attaches to that transitional period, for it was a time of remarkable activity and energy,—an activity which perhaps necessarily accompanies all periods of great social change.

It was at this juncture in the history of the world that men began to learn that war is not the normal condition of our existence, and that human happiness depends rather on social co-operation than on antagonism. They were then also learning to exercise a free judgment on many public and religious institutions. These great changes were accompanied by great changes in the moral perception and practice of fine art. Dwellings ceased to be castles; helm, corslet, and mail gave way to the silk and ermine of civic robes; and the houses of the great began to wear a new aspect when their occupants ceased to frown on their neighbours as on their natural enemies, and began to appreciate the smiles and graces of domestic life. Thus, nothing could be more joyous and peaceful in their aspect than the palaces of Venice that began to be built about this time; and when, at a somewhat later period in our own country and in neighbouring states, the harsh attributes of mediæval life yielded to the cultivation of peaceful arts, nothing could exceed the cheerful and attractive aspect of the mansions of the Elizabethan age: unrefined indeed, and occasionally clumsy and even grotesque, they were gay and lightsome,—often indeed so flooded with light, that as Bacon, who was familiar with such houses, says, "Men knew not where to be to be out of the light," so entirely had the secluded and fortified aspects of the earlier architecture been banished from them.

Among the changes brought about at this momentous epoch, none were more strongly marked than those which occurred in our own art; and the change which was in Italy gradually effected during the fifteenth century seems to have reached, as I have stated, its final completion towards the end of that century,—a period rendered so illustrious in the annals of art by the works of Raffaelle, Michael Angelo, and a brilliant host of others of kindred genius. Bramante, and his still more distinguished pupil Raffaelle, introduced in their architectural designs that union of perfect grace and simplicity which inclines me to assign the very beginning of the sixteenth century as the date of the greatest perfection of the Renaissance school, when modern architecture may perhaps be said to have attained a degree of excellence which has never been since exceeded. Among the most notable examples of this very remarkable but short period may be named the Loggia of the Vatican, the Pallazzo of the Cancellaria at Rome, the Palazzo Pandolfini, and a few other buildings which might be named as specimens of matchless purity of design.

As the painter's art freed itself from the conventional style of drawing and composition which had before prevailed, and became distinguished for truth, simplicity, and grace, so architecture in this its age of elevation—namely, the commmencement of the sixteenth century—will be found to be free alike from the grotesque tendency both in proportions and in ornamentation which occurs in the preceding age, and from the excesses and extravagance which grew up with the rapidity and profusion of weeds during the succeeding period. It is to be deeply regretted that Raffaelle did not live to transmit to us a greater variety of examples of architectural design, for undoubtedly he had as pure and refined a feeling for architecture as for the sister art. The great works of this illustrious man, whom the united voices of his own and of all subsequent ages, and of all civilised countries, have pronounced to be one of the most gifted sons of art, were executed within twenty years—namely, from 1500 to 1520—which must be regarded as the culminating period of modern art, including modern architecture. It will be profitable then to look back upon that short but brilliant epoch, and to pass under review some of the principal works which belong to it.

I have already noticed some of the contemporaneous social and political events which characterised this period of mental and æsthetic activity. Very few years sufficed to effect very great progress. The great changes in art were, as you well know, simultaneous, and perhaps in great measure connected with and consequent upon the important literary revolution which was at that time taking place. After lying for ages almost concealed, and certainly wholly neglected and uncultivated, classical literature was restored and rapidly developed, and it was natural that at the same time a congenial taste for the study of that classical art with which it was intimately connected should arise. While the Petrarchs and Politians were busied in exploring and unfolding the treasures of neglected libraries and defaced palimpsests, the researches and labour of the no less indefatigable lovers of ancient art were daily bringing to light the surviving evidences of its former excellence. The first artists of the period were indeed the most energetic archæologists. Buildings previously unknown were disinterred and diligently examined. We find Alberti, Bramante, Peruzzi, and Raffaelle himself, studying with exemplary pains the crumbling relics of antiquity, and with incredible zeal measuring and delineating those treasures, which, like the gold of new-found fields, had lain for centuries trodden under foot, disregarded and even unobserved. The effect of this ardent study soon made itself very visible in the works of these artists, and such was the fervour with which these studies was pursued, that the lifetime of each individual artist witnessed wonderful changes in all the arts of design.

It is not for me to expatiate on the changes so effected in the sister arts; I have already alluded to the singular evidence of progress as a painter in the twenty years of Raffaelle's artistic life. Unfortunately he built so little that we have not the means of tracing his progress in architecture; but in the works of his master, Bramante, we have more palpable evidence of the effects of his eager study of classic remains: his earlier works, as in the Cancellaria, with all their beauty show some indications of the archaic dryness of the fifteenth century in the working out of their details; whilst in his later works, as for example the memorable arcades of the Papal palace, a more accurate acquaintance with Classical details and Classical treatment of architectural forms becomes manifest. Vasari dwells with admiration on the zeal with which Bramante applied himself to the acquisition of an accurate knowledge of the style which had for so many centuries fallen into oblivion. In cultivating this style anew he was but following the popular impulse that had been given to the study of ancient architecture by the disinterment of Roman remains, both literary and artistic. But the peculiar energy of Bramante's character, and the favour which he enjoyed at the Papal court under Alexander VI. and Julius II., and which afforded him so wide a field for the exercise of his genius, rendered him perhaps the most influential and effective of all the promoters of classic art at the period to which we are referring.

---

* The third of a course of Lectures on Architecture delivered at the Royal Academy.

† See *ante* page 103.

Among the foremost of those who zealously seconded Bramante's efforts for the resuscitation of ancient architecture, was Baldassare Peruzzi. Although his immediate successor in the fabric of St. Peter's, Peruzzi was an artist of widely different character; of far less vigour but of much more refinement, most painstaking and laborious, but diffident, retiring, and unambitious, Peruzzi wanted those intrinsic qualities without which talent often fails to attract the merit which it deserves. Bramante, bold and energetic in the prosecution of his works, yet joyous and festive in his social habits, attained the highest favour and the utmost popularity; whilst his successor, of a very different turn of mind, lived, as his biographer tells us, amidst constant vexations and difficulties, and died in penury. Yet, in mockery as it were of his hard fate while living, a pompous monument was erected in his honour after death by the pope, in the Pantheon, close to the resting-place of his fellow-pupil Raffaelle.

There are lessons to be learnt from a careful study of the works of these earlier masters of the Renaissance to whom I have been referring, which I think it particularly behoves me to dwell upon in this place.

I can call to mind no work of the best masters of this period which does not clearly indicate that in their estimation it was a leading principle of design to distinguish very widely, and in a most marked manner, between the treatment of interior and exterior architecture. In the works of both the masters to whom I have adverted—namely, Bramante and Peruzzi, but perhaps more especially of the latter, a degree of interior ornamentation was indulged in that might to our cold northern tastes appear almost excessive, and which we should probably be disposed to condemn, were the excesses not redeemed, and I may say in most cases fully justified, by the extreme beauty of these ornamental details, and by the judicious treatment of them. Nothing, for example, can well exceed the elaborate elegance of the decorations of the halls and corridors of the two Massimi palaces at Rome, which I own struck me as among the most finished studies of interior architectural composition that I had ever seen. The rapid advance made towards the perfecting of the new style is rendered remarkably apparent by a comparison of the ornamental details of Bramante's Cancellaria with those of the highly finished works of Peruzzi to which I have just referred.

Now if we look to the exterior of these same buildings we shall find the most marked difference of treatment;—a general abstemiousness prevails in respect to mere ornamentation. The evidences of care and study in the composition of the leading forms as well as of the details are quite as apparent outside as within. There is not a moulding that does not bear the impress of thought and care; but you will find breadth and simplicity the chief objects aimed at throughout, whether in the principal features or in the minor details. It is clear that these great masters, with one accord, were wont to say to themselves, "We will indulge our love of the beautiful on the walls and ceilings of our saloons and corridors, where the eye has leisure to dwell upon them, and where, sheltered from the vicissitudes of the seasons, our cunning intricacies and our mimic foliage may endure, and be a permanent source of pleasant contemplation for future generations; but we must, in our exterior work, have regard to the altered circumstances of position. A building cannot be very critically examined, or even seen with convenience, from a very proximate point of view: the eye must be moved to some distance in order to appreciate or comprehend the design of the exterior when the building is large. It is not then in these elaborate details that we can hope to win the applause of cultivated critics; for in truth such details will be too far off to be seen. We must rather have regard to the *ensemble*, to pleasing outlines, to variety of light and shadow, to symmetrical arrangement of the several parts. Such are the considerations that must be foremost in our minds whilst we are designing external architecture. If we introduce on the outside the minute and intricate ornaments in which our fancy disports within, we shall find the breadth of our lights broken up, and their effect destroyed. We shall be inviting attention to details the merits of which will be unappreciated, and run the risk of losing the labour we have bestowed on the general composition, which may perchance pass unheeded by the eye, distracted in its attempts to examine unimportant minutiæ. Besides, architecture is a material art: it deals with substantial realities, and is wholly dependent on static laws. Moreover if we break up and obliterate our bounding lines, we shall deprive our work of the special character of architecture, and destroy its idiosyncrasy. It behoves us too to reflect that by raising up a structure composed of trivial littlenesses, and overlaid with festoons of little leaves, and flowers, and ribbons, or crowded with crockets, finials, and intricate corbelling, and by fretting the surface over with niches and imagery, and so forth, we shall be setting the elements against us. We shall find that the rain, and the frost, and the invisible chemical atmospheric agencies for ever acting with determined hostility against the substances we work in, will ultimately—possibly slowly, but perhaps rapidly, at all events most surely—render our sculptural labours nugatory, and perchance indeed annihilate our building; and if those who follow us are not perpetually employed in renovating our work—patching and mending, restoring or renewing—our structure will inevitably become a picturesque ruin, the established residence of bats and owls."

Such may have been the reasoning of those experienced, thoughtful, and sagacious masters who ruled the destinies of our art at the end of the fifteenth century; and hence we find that Raffaelle, when he designed the Palazzo Pandolfini at Florence, his work is a model of symmetry and elegance, but wholly without wreath, swagg, or crocket. It is the admired of all beholders, as much so now as when it was just erected; and lastly, it remains unaffected in its stability after exposure to the elements for three centuries and a half. The same discrimination in the use of decorative details will be found to characterise the architecture of the Vatican Loggia, the Cancellaria, and the Palazzo Massimi, at Rome; the Church of San Francesco at Rimini, the Palazzo del T at Mantua, and I believe I may add every other building by the leading artists of that memorable period which remains to us undisfigured by the hands of more recent spoilers.

I feel it incumbent on me to invite the attention of the student in architecture of the present day to a thoughtful consideration of this lesson, as taught us by the best masters of the best period of modern art. It is the more incumbent on me to do so, because it is impossible to deny that the fault of the present day is a tendency to excessive and inappropriate ornament.

I trust I shall be exonerated from any charge of personal criticism. I can truly say I have not the remotest idea of assailing individual sinners; it is the sin I would condemn. If we critically examine the growing architecture of any of our great commercial or manufacturing towns, we shall see ostentatious—I may call them presumptuous—edifices rising around us, in every possible respect the reverse of those graceful yet unassuming works to which I have been adverting. Their outside is decked out and weighed down by ornament, showy, obtrusive, and meretricious; whilst their interior presents usually bare black walls, as indeed they should be, seeing that they are occupied solely by clerks and merchandise. I cannot in too strong terms raise my feeble voice against this vulgarism, which, while it panders to the worst tastes of the uneducated throng, sets an example that tends to perpetuate the grievance, and to lower the standard of public taste by inuring our eyes to these pretentious solecisms. From warehouses and counting-houses the plague may spread to edifices of other and higher character.

But let us turn from the further contemplation of these unhappy errors; and as the Spartan youth were taught sobriety and moderation by the repulsive exhibition of vice in its worst forms, so let us hope that the exhibition of so much vicious taste may operate as a warning to our ingenuous youth, and thus tend to bring back architecture to its ancient and becoming purity.

Whilst thus venturing to denounce offences against purity and good taste, it may be permitted me to touch on what I am apprehensive must be regarded as another prevalent error—I mean the growing tendency to disregard consistency of style in design. By style in art I presume is meant a certain homogeneous system or manner of design, productive of a combination of analogous forms bearing an harmonious relation to each other. Thus when a particular style or manner is adopted and carefully adhered to, a pleasing effect is produced by the general air of consistency which is the result, even when higher æsthetic qualities are wanting.

To adhere accurately to any given style demands an intimate knowledge and close observation of its peculiarities, involving the necessity of a laborious and attentive study. This necessity is apt to breed a disposition, first, to depreciate, and then to disregard all study of this nature,—a study very unwelcome to the indolent and very distasteful to the self-sufficient student, who spurns the trammels of consistency, and who, ambitious to strike out a path of his own, would fain believe it to be beneath him to regard very narrowly the trodden paths and the more frequented highways of his art. No mistake is more dangerous than this;—the only safe ground for hope of future progress lies in a clear and comprehensive knowledge of the past; and he who is earnestly anxious to extend the bounds of art must first make himself thoroughly acquainted with all that lies within those bounds.

The contempt for consistency of style gives birth sometimes to very strange spectacles, many singular compounds of discordant types. We shall find perhaps very high-pitched roofs of French rococo work laid upon a structure having visible pretensions to Palladian art, whilst scattered glimpses of Elizabethan manner give to the heterogeneous mass still greater grotesqueness. Such are the deplorable results of the neglect of style. Be assured that no genius, however commanding, can indulge in these anomalies with impunity; whilst for the student of ordinary powers to venture upon them would be an act of imprudence which no sensible man would commit.

I may perhaps be told, that to inculcate so careful an adherence to style would be to set up a slavish doctrine,—to shackle the fancy, and to limit the freedom of genius. But this would be an error. As consistency of conduct in the ordinary affairs of life is an evidence of stability of judgment, so æsthetic consistency is a proof of a taste based on sound and intelligent principles. This consistency of style is peculiarly a mark of the best periods of art, and will never fail to be found to distinguish the productions of the best masters. If for example we examine the *chefs d'œuvres* of the thirteenth century, we shall be offended by no inconsistencies. One portion of the building appears to arise necessarily out of or to be necessarily dependent on the adjacent portions, and generally a natural sequence of parts tending to one homogeneous whole seems at once manifest;—a pervading principle, in short, appears throughout the structure. So in the best works of the great masters of the Renaissance period, there is a well regulated congruity of manner, testifying that the artist was influenced by fixed principles, and that his work was as much the result of good sense as of good taste; or rather, that these two qualities are necessarily associates of each other, for I cannot too strongly impress upon you how close a relationship it is which exists between them. The educated eye refuses to be pleased with that which is irreconcilable to reason, in however fascinating a form it may be presented to the eye.

It is for this reason that all false bearings in architecture are a deformity, for by offending the judgment they offend the taste. Every apparent insufficiency of support, every pillar and corbel and beam that is apparently incompetent to bear the weight charged upon it, disquiets the critical eye. I would suggest it to you as a useful exercise to test all the best works of architecture, of whatever date, with reference to this rule.

You will find for example the lower parts of the building always designed with fewer breaks, smaller openings, and generally a greater breadth of parts, in order to convey to the mind of an observer the idea of greater strength there than in the superstructure. An abundance of illustrative examples might readily be adduced, but it may be sufficient that I should name but two, both works of high repute, and familiar to all—the Campanile at Florence, and the Doge's palace at Venice. In the former, stability is one of its most prominent characteristics. Giotto its author was, we know, remarkable for his constructive sagacity; and his biographer reports to us the infinite pains he took to secure the stability of his work, fashioning each individual stone to its special place and purpose. Yet we see plainly that he was equally anxious to give to his tower the appearance as well as the reality of strength. In truth, to act otherwise would have been to practise a species of architectural jugglery, which was far beneath the dignity of his art, as well as inconsistent with his character as an artist. He built a tower, in short, which has stood unmoved for six centuries, and bears upon its very aspect the promise of permanence during at least another like period. In the Doge's palace at Venice, on the contrary, we see a building, which is no doubt strong enough, for it has stood some centuries, but in which all its beauty of detail will not redeem it from the charge of being built in defiance of static propriety. A vast, plain, ponderous mass of brick walling, lightened by few windows, relieved by very few breaks, is upheld by a continuous row of not very substantial looking arches, ultimately resting on pillars of no great bulk, and having scarcely a base to receive them.

In the tower at Florence we see solidity below and lightness above; whilst in the palace at Venice all the solidity is above, and the substructure is weakened, or apparently weakened—which is sufficient for my argument—by a series of deep perforations or excavations. To give a structure of adequate strength the appearance of infirmity is a gratuitous piece of absurdity, which no ingenuity of construction or beauty of detail will justify.

Were it necessary to enforce this principle by further illustrations I might invite you to compare the dome of the Pantheon with that of St. Peter's; the latter growing abruptly out of and apparently resting on a flat roof, the former, on the contrary, having all the attributes of strength, its weight visibly and adequately borne by walls traceable down to the earth, upon which it manifestly reposes. It is but doing justice to the memory of the great artist who first designed St. Peter's, to add, that this serious æsthetic error is due to a departure from his original design.

Let us revert now to the consideration of the works of that particular period to which I have for the most part confined my remarks on the present occasion. I have called your attention to the general propriety of design that pervades the works of the best masters of the period; and I have shown how invariably they kept in mind the difference which it is obviously and naturally desirable to preserve between the treatment of interior and exterior architecture. I have attempted to show, too, how discriminating they were in the use of ornament, exercising a wise and judicious abstemiousness, or a generous profusion, according to the relative position of the work and the character of the building.

I would now invite you to observe how careful those masters were to consider well the nature of the situation of their work, and the difference which they evidently thought it fitting to maintain between works of architecture erected in cities, and those which are erected amidst natural scenery. In these two cases the building is seen under circumstances so widely different, that a corresponding difference of treatment seems obviously called for. A certain air of reserve and dignity, a subdued formality of manner, seems the most appropriate average character for buildings in the one case, whilst a *riant* and playful aspect seems generally the most appropriate in the other; although no doubt it would not be difficult to state exceptions, still I apprehend that such is the broad distinction which may aptly and properly be laid down.

In civic architecture, then, though there may be contrasts in the colour of the several parts, as well as in the form and ornamentation of the several features of the design, still it is expedient I think to preserve a generally symmetrical arrangement and uniformity of appearance, in order to give to the work that staidness of character which seems most in accordance with civic life.

My observation is intended of course to apply with more force to buildings of a public nature, but it applies also with, I think, but little less force to domestic architecture. In the thoroughfares of a great city, good taste suggests that individual feeling should give way to public considerations; and a man who obtrudes his residence upon the public notice too conspicuously, lays himself open to the charge of a vulgar presumption. Hemmed in as every building usually is, whether private or public, by numerous other buildings, when in the centre of a town, each is liable to be judged with reference to its neighbour, and each group of buildings forms, or should form, a homogeneous whole. I must not be so far mistaken as to be supposed to recommend that cold, monotonous uniformity, which we occasionally meet with in continental cities, and too frequently in our own. Yet, too great a variety of treatment should not, I think, be indulged in. I have however already on a former occasion ventured to express this opinion, I will not therefore further insist on it.

Widely different are the circumstances attending rural architecture, surrounded by the endless variety of natural objects, where those with which our work is in contact, or in the immediate proximity of which our building stands, are broken into many parts and into various altitudes. To group well and to amalgamate agreeably with such forms, a building must not be marked by too great severity of aspect; it should be broken and somewhat diversified in form and *chiaroscuro*.

This is the sentiment that seems constantly to have influenced the best masters, not of the age only to which I have this evening been particularly referring, but of every age when accomplished architects have existed. Look, for example, at the Villa de Medici at Rome, attributed in great part at least to Michael Angelo. The front next the city, where it is placed formally in the presence of other buildings, presents a somewhat plain, uniform, and pefectly symmetrical design; whilst the rear of the very same building, where the façade is surrounded by the varied accompaniments of ornamental gardening, parterres, fountains, terraces, and the like, assumes a totally different character; its outlines seem to relax into the picturesque and irregular. So that beautiful villa in the vicinity of Rome, well known to all who have visited that city—the Villa Doria Pamfili. Abounding in sculpture of the most rich and elegant character, it seems to be in perfect harmony with the smiling gardens with which it is associated; so harmonious indeed that the edifice appears to grow imperceptibly out of the terraces which surround it, and one can hardly define where the domain of the gardener ends and that of the architect begins. Compare this villa, its broken outlines and varied heights, with the palaces of the best masters in the adjacent city, such as the Palazzo Farnese, and others that might be readily named, and you will see in the latter dignified masses of architecture with unbroken outlines, generally of uniform height, and always great moderation in the use of ornament. Look too at the Villa Pia, by Pirro Ligorio, a contemporary of Michael Angelo; the light and graceful building scatters itself, as it were, over the gardens of the Belvedere, in the freest and most fantastic manner; while the same artist when he designed the Palazzo Lancelotti, at no great distance off, but in the streets of Rome, produced a simple, grave, uniform, and almost heavy structure.

But evidences of the systematic adherence to this principle of design crowd upon our recollection among the works of the most eminent in the age of which we are speaking. Palladio adorned the cities of the North of Italy with buildings that have ever since been the types of architectural beauty; but I remember not one example of a strictly civic building of his design that does not, with all its elegance and refinement, preserve a somewhat subdued, dignified, and decorous tone, marked by the uniformity and simplicity of its general lines; whilst the same architect, when relieved from the restraint apparently imposed on his pencil by the publicity as it were of the site, will never fail to be found to relax into a freer and more playful design. I need hardly do more than remind you of the graceful Villa Capri, on the banks of the Brenta, those banks so rich in examples of that fine taste which distinguished Italian art in the earlier half of the sixteenth century, yet abounding also, it must be owned, in architectural *capriccios* of a very different character of a later date.

When adverting to the excellence of the masters at this auspicious period, it behoves me not wholly to omit certain other illustrious names. Among the immediate followers of Raffaelle, none I think deserves our regard more than Giulio Romano. He was one of the master spirits of that remarkable age. Whether as an engineer engaged on the drainage of the marshes of the Po and the Mincio; or as a painter of the very highest powers, and endowed, in the opinion of Sir Joshua Reynolds, with a poetic genius beyond that of any painter before or since; or as an architect, the designer of the Villa Madama at Rome, and of the Palazzo del T at Mantua,—in whatever light we view him we must place him in the first rank of those who by their works have bequeathed to us important lessons in our art. As architect only I presume to speak of him here; and as such certainly he was fully worthy of his great master Raffaelle, and of the period at which he lived. To the Mantuan palace I would point as a striking illustration of the principle of design to which I have been adverting. With all its elegance nothing can well exceed the extreme simplicity of the exterior of that building, although built for the personal enjoyment and under the eye of a prince devotedly fond of art, and with the command of abundant means, Giulio Romano has lavished on his work no pompous Corinthian display; he has indulged in no superfluities of friezes, festoons, and foliage. There is not, in fact, a single column in the whole building, although it is true we see on every inch of surface ample evidence of the nicest taste, and of infinite painstaking in the adjustment of the proportions of each individual part as well as of the whole. Such is the character of the exterior. It would difficult to form an adequate conception of the obloquy that would be the fate of any mistaken individual who in these days of masonic floriculture would dare to erect so plain a building in Hyde-park. Poor, tame, heavy, barren, cold, dry, &c., such are a few of the adjectives that would be contumeliously assigned to the unhappy artist by the current criticism of the day. Such however is the character of the exterior which Giulio Romano, the favourite pupil of Raffaelle, thought proper to give to the outside of his royal master's palace. But enter that palace, and you will there find the poetic genius of the artist in all its radiance; the richest display of all the three sister arts in happiest combination and in most generous abundance.

It might seem superfluous to dwell so much in detail on a principle the propriety of which appears too obvious to need enforcing, but he must be little versed in the erring tendencies of our art, and in the eccentricities of her votaries, who will not admit but too readily that the principle I urge has been far too often deplorably overlooked. How often do we meet in situations of the most romantic beauty with buildings of that Bœotian age of English architecture, the latter part of the last century, whose plain, heavy, cubical masses too truly deserve the ridicule of Uvedale Price, who likens to a "a huge clump of bricks" their ungainly shape, "if shape it may be called which shape hath none." How often too may we encounter, in the very heart of our soot-begrimed towns, some tawdry piece of affected picturesqueness, obtruding itself on us like an ill-timed joke, jarring on the feelings, and out of tune with the tone of the mind.

Having now touched upon the merits of some few of the most distinguished among the worthies of the earlier part of the sixteenth century, I have but little time left to review the merits of those artists who illustrated the remainder of the century. Indeed, to do even the scantiest justice to that brilliant epoch we need a long course of lectures, and what is far more important, a long course of study. It is a singular fact in the history of our art that, limiting our view to the period of modern civilisation, nearly all that is excellent in architecture will be found to be centred within about a hundred years, dating from the latter end of the fifteenth to the latter end of the sixteenth century, and that, too, within very narrow geographical limits—namely, the northern and central parts of the Italian peninsula. No doubt within that period works of great merit and genius may be found outside those geographical limits; but they will prove on examination to be for the most part but weak and inferior emanations from the real active centre to which I have referred. Italy was in fact the school of art for all Europe, and whatever was fine at that period in France, Germany, and I believe I may add Spain, may be traced to an Italian origin, for Italian artists scattered themselves over those countries, or by their teaching and example influenced the progress of art there. Of course I here speak not of our own country, for we had then hardly emerged from Mediævalism, and our art then formed part of a totally different cycle, and belonged to another civilisation.

In stating that the culminating period of what we call by the borrowed term "the Renaissance," extends from the latter part of the fifteenth century to the latter part of the sixteenth century, I would observe that even within those hundred years it is by no means to be asserted that an equally sustained excellence prevailed. For whilst in the north of Italy, Palladio, Sansovino, and others nobly sustained the character of their art, the Roman school certainly deteriorated within that period.

Michael Angelo was beyond any question whatever one of the greatest artists the world has yet known, and it seems almost profane to utter a single derogatory syllable respecting him, especially within these walls, where his transcendent merits have been so often recognised and proclaimed; yet truth, or at least what I honestly believe to be the truth, obliges me to say, that the intense vigour and potent genius of Michael Angelo led him to set examples which did in fact, through his numerous and less-gifted imitators, very seriously debase the Roman school of architecture.

In the earlier, purer days every form had its mechanical purpose, and every stone its special use, and even every ornament was but an emphasized stone. In the works of Bramante, and Raffaelle, and Giulio Romano, the removal of a single ornament would have been a manifest mutilation of the building; whereas in the works of the later masters ornament became a redundancy—an object that would seem to be capable of being plucked away or hacked off without any concern to the fabric itself. These decorative adjuncts were, I am most ready to admit, often very beautiful works in themselves, but their individual beauty is no justification of them when improperly placed, or when used for the unworthy purpose of winning applause for their novelty alone or for their fine execution.

A learned divine of the last century, speaking as a literary censor, says, "Vicious examples are most noxious when set off and recommended by the charms of oratory and poetry; as some poisonous plants growing on a mountain in China are said to kill only when they are in flower." So was it with the seductive embellishments of artists who, heedless of the simple habits of their predecessors, cultivated a noxious exuberance of ornament; degenerating from plenty into excess, from legitimate indulgence into a sort of æsthetic inebriety; wholly forgetting that the highest art and the most commanding powers must submit to be subject to the guidance of reason and good sense.

It is therefore that I have on this occasion held out for your special consideration and study the works of the distinguished men of those better times to which I refer. I would recommend to you to ascertain exactly wherein their merits appeared to lie, and what were their faults. Consider well how the peculiarities of each master's style arose out of the circumstances of the time when he lived, or from the climate under which he worked, or from some other local circumstances; and however much you may admire or even reverence his style, think how far it suits our modern English wants before you adopt any portion of it as your own.

I know some very transcendental critics may say, "Why adopt any other man's ideas? Scorn rather to repeat that which has been done, and let every idea that you embody in brick and stone be your own original conception, the offspring of your own pure invention." Such advice would be founded on a theory most attractive and exalted; but it is a theory which I should fear to recommend here for your unrestrained, unqualified adoption. Some of the most atrocious sins in our art have been committed under the influence of this seductive and dangerous theory. Under the flattering term of invention men have indulged in the vainest conceits, and have perpetuated in stone some of the most ridiculous errors. I feel it to be my duty, at the risk perhaps of being charged with timidity and want of vigour, to advise the young student not to allow his ambition to seduce him into abortive attempts at novelty.

An eminent writer of the seventeenth century says with much point—"A man coins not a new word without some peril, and less fruit; for if it happen to be received the praise is but moderate, if refused the scorn is assured." It is in truth the privilege only of the highest genius to venture upon deliberate innovations upon established modes of expression, or to add to his native vocabulary; and the ordinary student would do wisely to confine himself to that which has received the sanction of time.

Such, too, are the risks run by him who without the utmost circumspection would venture to coin new forms and arrangements of architecture. Nor am I imposing on him any severe restraint. A wide field still lies open before him for the exercise of his imagination, and for the production of beauty and grandeur. He may find his ingenuity sufficiently taxed in doing that well, without even attempting to mount into the higher regions of imagination. To torment his brain by spasmodic attempts at novelty, when the result of that effort is perhaps but to do what might just as well have been done by ordinary means, is like a man who would prefer to lose himself in the tangled forest rather than submit to pursue the path that is straight before him.

Let the student then and the younger practitioner beware lest he be led into danger and difficulties in the pursuit of so unsafe an object—so treacherous an *ignis fatuus* as mere novelty. The good general is he who, in preparing for an engagement, begins by making himself thoroughly acquainted with his fighting-ground,—who ascertains his weak points and strengthens them, and secures his ground by first making himself intimately acquainted with its capabilities. Such I apprehend would be his surest way of effecting a permanent and safe advance and of securing ultimate triumphs; and such I apprehend is the type of that process by which in our art real progress may be made and her true interests promoted.

Above all things, enter into no sectarian views: do not confine your studies to the narrow limits of a special period or style. Were a man to open a book in one place only, and after thumbing and dog's-earing the one page to leave the rest uncared for and unread, his profit would be small, and his knowledge of the book extremely limited. The great volume of our art must be read with no such parsimony of labour; for no deep and compendious knowledge of the subject of that volume will be acquired without a diligent, impartial, painstaking study of all its pages.

THE THUL GHAUT INCLINE ON THE GREAT INDIAN PENINSULA RAILWAY.

This great undertaking, and its predecessor on the same railway, the Bhore Ghaut incline, are rendered especially interesting by their magnitude, practical characteristics, and by the fact that they are situated in a country where, with all the advantages of the national enterprise and government support of England, success, economy, and despatch were dependent upon the resources of a foreign and distant land.

The Thul Ghaut incline was described by Mr. Jas. J. Berkley, chief resident engineer of the Great Indian Peninsula Railway, in an address delivered to the members of the Bombay Mechanics' Institution, in December last. A paper on the Bhore Ghaut Incline by the same author was read before that institution three years since, a report of which will be found at page 247, vol. xxi. of this Journal. Mr. Berkley mentions some of the peculiar features in which both a resemblance and a contrast may be traced between these two inclines. He says—

"Both of them ascend the same chain of mountains, in which the geological formation is similar. The altitudes of the two Ghauts closely correspond; the summit of the Bhore Ghaut incline being 2027 feet, and that of the Thul Ghaut 1912 feet above the sea. Both of the ascents are effected in proximity to the public mail roads. The maximum gradient of both inclines is the same, being 1 in 37. The extreme curvature is almost identical, that of the Bhore Ghaut being 15 chains, and of the Thul 17 chains radius. The character of the incline has in each case been improved by the adoption of the same contrivance of a reversing station, and under singularly parallel circumstances. The same description of permanent way is being adopted for them both. In local peculiarities we find the same difficulty in procuring a due supply of water for our labourers and works.

The points of variance between the two inclines are numerous and remarkable. It is true that they traverse the same chain of mountains, yet the clue to the laying out of the railway in each case was as different as can well be conceived. For instance, at the Bhore Ghaut the course of the great ravine of the river Oolassa defined the general route of our railway ascent from the base to the summit; whereas at the Thul Ghaut the accidental existence of the Koshen, Lara, and Mussoba Khinds, or passes through the hills, were our principal guide to the selection of the line we are constructing. They are cut through the same geological formation; but upon the Bhore Ghaut we frequently find the mountains precipitously scarped, and have to deal with deep faces of bare rock. Not so upon the Thul, for the physical contour of the hills generally presents an undulating surface, and the rock is covered with a thick superstratum of moorum and boulders, so that it is only for short lengths near the summit that an escarpment is encountered. In the tunnels of the Bhore Ghaut incline we have certainly exposed several varieties of trap-rock with which our geologists are familiar; but in the estimation of a miner they are invariably hard. The circumstances of the Thul Ghaut tunnels are of a very different nature; for there we have to deal with extremes of hardness, earthiness, dryness, and a copious flow of water.

The altitudes of the two Ghauts above the sea are very nearly equal upon both ascents; yet the height to be surmounted by the Thul incline proper is only 972 feet as compared with 1831 feet upon the Bhore. This great disparity in the height of the inclines arises from a remarkable variation in the physical geography of the two districts; for while at the Bhore Ghaut the mountain spur abruptly terminates at a distance in a straight line of only 11 miles from the crest of the main range, that upon which the north-eastern extension has been laid out stretches for 30 miles westward into the Concan, and ends in scattered hills within a short distance of the sea-shore. Although a public road exists in the vicinity of both Ghauts, they afford very unequal facilities to our works. The Bhore Ghaut road is steep, tortuous, and ill-made; nor does it touch upon the line, or yield us any accommodation, except on its near approach to Khandalla. On the other hand the Thul Ghaut road is a masterpiece of engineering, and is in no part distant from the railway works. Indeed for 7 out of 9½ miles it lies within a stone's-throw of them. It has been compulsory to adopt the same maximum gradient of 1 in 37 along a portion of both inclines, yet at the Thul Ghaut we have been able to flatten the plane to a very considerable degree for a distance of nearly one-third the ascent. Upon the Bhore Ghaut we have derived some advantages from the station of Khandalla, with its bazaar and water supply; while in the vicinity of the Thul Ghaut the villages are small and remote. Egutpoora, and especially Kussarah, have however greatly increased, and appear at the present time to be reaping the benefits of our works by a thriving trade. Both of the inclines possess the peculiarity of presenting upon their section an enormous mass of heavy work; and although in this respect the magnitude of the Bhore Ghaut incline very far surpasses that of the Thul, yet we have been compelled upon the latter to design works of grander dimensions; and its longest tunnel and viaduct exceed anything to be met with on the Bhore Ghaut section. Indeed, the unusual proportions of the Ehegaum viaduct have driven us to another distinguishing expedient, in the adoption of iron girders of 150 feet span, instead of the stone arches which it has been our practice to build at the Bhore Ghaut.

There is one other discrepancy of practical importance. It is the fact of the railway having been opened to the foot of the Bhore Ghaut incline at the commencement of the works; whereas upon the Thul Ghaut we have had for the last three years to labour at the haulage of our heavy materials along an indifferent road from Wassind to Kussarah. This description will serve to show that, while in some general points the two inclines are strictly analogous, they display many essential and peculiar features which materially distinguish them in their scientific aspects, as well as in regard to construction and to the working properties of the railway."

The author describes the long preliminary operations in designing, and establishing the merits of, the Thul Ghaut incline, and the official delays and difficulties which had to be dealt with in connection with the Thul Ghaut project; and then proceeds to describe the works themselves.

"The railway incline now constructing at the Thul Ghaut commences upon the left bank of the Rotunda Nullah, near the Bombay and Agra road, and proceeds over some heavy ground with one tunnel, through the Lara Khind to the Mandasheyt Nullah, which it crosses by means of a large viaduct. It then perforates a high spur of the mountains by a long tunnel. Emerging from this it passes over two rocky ravines, and through the intervening ridge by a tunnel. It thence ascends along the flank of the hills which overhang the village of Kussara, and spanning the Kussara Nullah by a viaduct, crosses the Thul Ghaut road below the toll-house, and enters upon the site selected for the reversing station, between the mail road and the Paithur Nullah. The reversing station is very similar in its engineering and physical characteristics to that of the Bhore Ghaut. From the reversing station the line strikes out at an acute angle through the Mussoba Khind, and rises by a curvilineal route along the northern flank of the lofty mountain called 'Beulah,' the spurs and ravines of which have necessitated the construction of several tunnels and two viaducts. After leaving our longest tunnel the incline crosses the enormous gorge at the head of the Ehegaum Nullah by a viaduct of extreme dimensions; and, traversing very rough ground by means of high embankments and two tunnels, it enters nearly at right angles the spur up which runs the old Ghaut road. With another tunnel through this hill it reaches the left bank of the Beena Nullah, which it crosses and recrosses by two bridges, and then ascends to the summit upon the open level ground close to the mail road on the western side of the village of Egutpoora. This incline is 9 miles 26 chains long; the level of its base is 940 feet, and of its summit 1912 feet above high-water mark in Bombay, so that its total altitude is 972 feet. Its average gradient is consequently 1 in 56, that of the Bhore Ghaut being 1 in 48. The gradients, which are all ascending, are as follows:—

	Miles	chains.		Miles	chains.
Level	0	2	1 in 88	0	35
1 in 60	0	47	Level	0	20
Level	0	16	1 in 60	0	10
1 in 60	1	3	1 in 37	4	29
1 in 50	0	42	1 in 45	0	18
Level	0	8	1 in 102	0	70
1 in 60	0	35	Level	0	12
1 in 148	0	23			

The curves are—

	Miles	chains.
17 chains radius	0	33 long.
20 chains radius	0	47 „
Between 20 and 30 chains radius	1	33 „
„ 30 and 40 chains radius	2	68 „
„ 40 and 50 chains radius	0	10 „
60 chains radius	0	39 „
80 chains radius	0	24 „
100 chains radius...	0	4 „
Straight	3	27 „

The works consist of 13 tunnels, of an aggregate length of 2652 yards, and of the following respective lengths:—

	Yards.		Yards.
Tunnel No. 1	130	Tunnel No. 8	412
„ 2	490	„ 9	70
„ 3	80	„ 10	50
„ 4	235	„ 11	261
„ 5	113	„ 12	140
„ 6	123	„ 13	58
„ 7	490		

So that upon the Ghaut inclines we are at present making as many as 38 tunnels.

There are six viaducts, of the following dimensions:—

	Yards		feet	
Viaduct No. 1	66	long	90	high.
„ 2	143	„	84	„
„ 3	66	„	87	„
„ 4	66	„	90	„
„ 5	250	„	200	„
„ 6	150	„	60	„

The total quantity of cutting amounts to 1,241,000 cubic yards. The greatest depth of cutting is 60 feet, and the largest cuttings contain—

Cutting No. 1	58,000	cubic yards.
„ 6	40,000	„

The quantity of embankment amounts to 1,245,000 cubic yards. Their maximum height is 90 feet, and the heaviest embankments contain—

Embankment No. 4	190,000	cubic yards.
„ 6	90,000	„
„ 18	220,000	„

These details of the earthwork will be liable to alteration during construction, in order to provide for the security of the line by flatter slopes wherever the material may prove to be of a soft or treacherous nature. There are 15 bridges, of various spans from 7 to 30 feet, and 62 culverts.

The estimated cost of this incline is about £45,000 per mile, and its completion has been contracted for on the 31st May, 1863. The probable cost of the Bhore Ghaut will be about £46,000 per mile. This presents conclusive evidence that mile for mile the works of the Thul Ghaut are nearly as extensive as those of its formidable rival. The tunnels all contain trap-rock, and the two near the bottom of the incline consist throughout of basalt of the hardest description. Of these, the Mandasheyt tunnel, 490 yards long, deserves more particular notice. The process of blasting the basalt which it contains was so slow, that it has been necessary, at considerable cost, to sink two shafts; and as these are charged with water during six months of the year, we find our operations encumbered not only with the difficulties of mining such extremely hard rock, for which steel drills are used, but also with the contingency of pumping. It is probably upon this work that the completion of the incline will ultimately depend; and situated as it is near the foot of the Ghauts, and attended with every disadvantage, it will call for the utmost exertions and perseverance to accomplish in due time that important object. The only other tunnel upon which I shall offer any observation is the long one near the middle of the incline. Its great length formerly led us to regard it as the key to the opening of a railway communication up the Ghaut; but on proceeding with our mining operations we fortunately discovered that the mass of the hill consisted of rock of a favourable nature; and the consequence has been that, although the work was not begun until March 1859, we have already carried a heading through 258 lineal yards, or about five-ninths of the total length of the tunnel, in one year and a half. No progress which we have hitherto attained has equalled the rapidity with which this tunnel has been executed; so you see a prize may be drawn even in the lottery of Ghaut contingencies.

Of the six viaducts there are three which specially invite attention. The Mandasheyt viaduct, at the entrance to the tunnel of that name, is a large structure, already in a very forward state. The great viaduct over the Ehegaum ravine is believed to be the highest viaduct that has been designed in India. The level of the railway is 188 feet above the surface of the ground, and as we have a depth of upwards of 20 feet to excavate for good foundations, the two central piers will be 200 feet high. The iron girders will be on Warren's principle, and 150 feet in span from end to end. One practical difficulty which lies before us is the lifting the girders from the bottom of the ravine to their resting place upon the tops of those lofty piers. The difficulty of the problem consists not so much in the weight of the girders (each of which may be calculated at about 32 tons), but in the following peculiarities:—that the triangular girders, strong as they are when framed complete for sustaining a vertical pressure, are laterally very weak; and that the ends of the girders, which are to bear upon the piers and abutments, must be carried up through recesses in the masonry. To obviate the imminent risk of damage to the girders from lateral motion while they are being lifted separately so great a height as 200 feet, we have made our arrangements for hoisting them in pairs, so that they may be stiffened by those connecting parts which are intended to steady them when the permanent road is laid. To lift them in pairs, as we propose to do, will require a recess 8 ft. 6 in. wide and 4 feet deep in each side of the piers, from the surface of the ground to the bed of the girders; and you will thus observe that the design of the piers, themselves of that enormous height, has demanded careful study. The plan we have adopted is to build a rectangular pier 15 ft. 6 in. thick, with two counterforts at each corner of the recesses. By this means we have not only strengthened that part of the pier which would be endangered by the existence of the recesses, but without adding materially to the quantity of masonry we have increased the steadiness and stability of the whole structure by widening its base. The lifting power to be employed might consist either of crabs or screws, but as the motion of the screw is so smooth and its action so regular, we intend to use it for hoisting, and crabs for securing the girders against any accidents in the process. The screw will be placed upon the top of the pier, and immediately over the recess. From it will be suspended strong iron links, each several feet in length, down to the top table of the girders; the lifting will then commence, and as the girders ascend they will be propped from stage to stage, and the links be successively disconnected as the girders rise in pairs towards their bed upon the viaduct. Should any casualty happen in the performance of this operation, we shall be prepared with crabs and derricks and strong chains to keep a constant hold of the girders, and thus prevent any fall or jerk while they are suspended on the lift. The present condition of this stupendous work is already worthy of examination, from the admirable arrangements which the contractors (Messrs. Wythes and Jackson) have made for its execution, and in which the peculiar form of the great ravine has afforded them extraordinary facilities. As it advances, the proximity of this colossal viaduct to the public road, the magnitude of its dimensions, and the peculiarity of its design, will no doubt be deemed by many travellers a sufficient inducement to pay a visit to the scene of operations; and the viaduct will I trust, when finished, with its iron superstructure and its lofty piers, be no unworthy memorial of the bold enterprise and practical skill of our countrymen, as well as of the excellent materials and industrial classes of India.

The last viaduct to be here noticed is that situated at the upper end of the tunnel under the old Thul Ghaut road; and although its design presents no peculiar feature, its position is remarkable, for it will stand upon a rock scarp overhanging the gorge of the Beena Nullah, the piers and abutments being notched and bedded into the rock escarpment.

In the earthwork there is little to claim attention, except the mode by which large quantities of materials are tipped into such high embankments as those three which are near the base and middle of the incline. The material of which they are made has to be procured from the bottoms and sides of the adjacent hills at suitable and various levels; and from the faces where these side cuttings are excavated, temporary waggon-tramways are laid to the embankment. In one of the large embankments there are twenty-seven, and in another sixteen, different lines of tramway in daily use for the conveyance of the earth. The lofty embankment above the reversing station is likewise remarkable, for it will have to be made in such a manner as to carry two double lines of railway, one of which will stand at an extreme height of 51 feet above the other. It will also present another peculiarity, for the lower line upon one side of the embankment will ascend towards the reversing station, while the upper line will rise rapidly away from it. The large viaduct which spans the public road a quarter of a mile above the toll-house, upon the Bhore Ghaut incline, corresponds by a close analogy of position with the embankment now being described upon the Thul Ghaut incline; and it may therefore be well to explain the reason why in one case a viaduct should have been designed, while in the other the object is effected by earthwork. At the Bhore Ghaut the railway at that point stands upon the narrow crest of a hill, and if an embankment had been made its slopes would have descended the mountain sides to an enormous depth, and its stability have been constantly endangered. Upon the Thul Ghaut on the contrary, the two lines, which are in close contiguity on emerging from the reversing station, pass over a nearly level plot of ground, affording a safe and firm basement for the bank. We have therefore economically adopted that course which would on the Bhore Ghaut have been attended with so much damage to the permanent safety of the incline.

In my previous paper on the Bhore Ghaut incline allusion was made to the extensive slips which were apprehended upon the slopes of its cuttings; and in that respect the works of the Thul Ghaut present the same demand upon the vigilance and precautions of our engineers. To anyone not conversant with the details of the works, the appearance of these casualties would no doubt give rise to serious misgivings concerning the ultimate security of portions of the railway; but we who are engaged in these extensive operations have the ground constantly before our eyes, and its every movement becomes familiar to us. The practice and experience of several years, and the instructive effects of our heavy monsoons, will enable us to overcome the contingencies of the Ghaut hill-sides with complete success.

If I now give the names of my colleagues in the engineering department of the undertaking, who have taken part in our operations, it may give some idea of the great amount of professional labour that has been bestowed upon a section of only 9½ miles of railway. They are Messrs. Ker, Graham, Darke, W. J. Wright (deceased), Inglis, Sanderson, Butt, Gale, Winteringham, Dickenson, A. A. West, Tate, F. A. Hawkes, Teasdale, Dangerfield, O'Brien, Cameron, Thompson, and Pocock."

A just tribute to the memory of Robert Stephenson follows, pointing out how greatly India is indebted to him for the exercise of his great professional weight in obtaining the introduction of railways into that country; and in which we heartily concur. Mr. Berkley says—

"But above all, there is one element of our unity and strength, one talisman of our success, in the great name of Stephenson! This is the first and a very appropriate occasion for me publicly to declare how much the railway system of Western India owes to our late consulting engineer. It was mainly upon the favourable report of Robert Stephenson that the government resolved to take the bold step of introducing railways into this country. They were then regarded merely as experimental, and strange notions had been formed of their incompatibility with the means and habits of the people; yet, encouraged by his opinion, the government of the day entered into that contract with the Great Indian Peninsula Railway Company which has formed the basis of our subsequent proceedings. It was Robert Stephenson who created the large professional establishment by which our designs and works are being accomplished. He it was who, with the able aid of George Berkley, our present consulting engineer, adopted and procured those vast supplies of mechanical appliances which the British Islands have contributed to our wants. By his influence, and the shelter of his prestige, we were enabled to find eminent contractors to undertake the execution of our extensive works; and it was to his council the government appealed with confidence in any doubt or difficulty that beset the prosecution of our plans. He indeed has been the one great bond that has cemented all the practical members of the executive of this immense concern, just as his experience and example, and those of his distinguished father, have constituted the principle of all our designs and operations. When I visited him last year he thoroughly acquainted himself with the details of our Ghaut inclines, and although I had previously felt considerable anxiety lest his long familiarity with works on a gigantic scale should lead him to entertain a less flattering appreciation of our Ghaut ascents; yet, to my infinite delight, I discovered that he of all men was the one who formed the most accurate and generous conception of the magnitude and difficulty of those undertakings. I deeply lament that he was not permitted to fulfil his intention of visiting this Presidency; for while he would have witnessed for himself the progress of our works, several public projects of Bombay would have derived inestimable benefit from his presence and advice. After a connection of eleven years with Indian railways, and within a short period of the completion of our Ghaut inclines, I grieve to say that we can now no longer look for his influence to support, his example to guide, his advice to help, or his approbation to animate us in our arduous labours. Still, if his loss be great to us who are conducting merely one small section of the great railway system of the age, how severely must it be felt throughout that wide range of public undertakings with which he was identified. Nor is it alone in connection with his own works that we can form a just estimate of his claim upon the gratitude and admiration of his country. His professional life displayed a powerful inventive intellect, a sound judgment, a clear perception and philosophical appreciation of facts, a thorough knowledge of physical laws, a strong grasp of science, which made it subservient to all the practical purposes of his essentially useful projects, and a strict regard for that wise economy which, aiming not solely at saving money, keeps expenditure in its due proportion to every important feature of the scheme. These were undoubtedly precious gifts, but the influence and position they acquired were strengthened by a noble disposition, which won for him the zeal and attachment of all whose agency was instrumental to his great designs, and the esteem of everyone with whom he was associated. All his dealings with men of business were characterised by fairness and generosity; and who can fail to admire that fine balance of mind which imparted to his decisions the accuracy of law, yet tempered them with the experience and sympathies of the man? His magnificent railways in all parts of the world, his colossal bridges—the Berwick, the Newcastle, the Victoria, and the Britannia,—these are lasting monuments of his fame; but his greatest triumph was the establishment of a general and acknowledged principle of equity in the control of public works, which derived its force and prevalence from his illustrious career. It may be difficult for the present audience to attach this result to the practice and example of Robert Stephenson; but there are thousands in England who, from their own personal experience, will heartily concede that honour to his reputation. And let not the value of this principle be disparaged. It has tended in a remarkable degree to aid public enterprise, by commanding the extraordinary resources of capital; by extending the powerful agency of the contract system; by concentrating the skill and exertions of vast bodies of able men drawn from the working classes of England, and by establishing a feeling of confidence between them and their employers. If the progress of such grand undertakings as have left our age without a rival in the history of the civilised world is to be maintained, then the sterling principles of equity, and the just appreciation of the interests of others, which contributed so much to Stephenson's renown, must continue to be the guide of all who may succeed him in conducting them. I earnestly hope, that so long as those tunnels which we are now piercing through the 'everlasting hills,' so long as those massive structures which are now uprearing their lofty forms in the ravines and depressions of our Western Ghauts, shall endure, the honoured names of George and Robert Stephenson may be remembered in this distant region, which will assuredly prosper, even as their native land has prospered, by their genius."

NOTES ON THE NATURE AND ACTION OF STEAM IN RELATION TO BOILER EXPLOSIONS.

At a meeting of the Literary and Philosophical Society, at Manchester, on the 2nd ult., a paper entitled as above was read by Mr. J. C. Dyer, the vice-president, in which he stated that several essays on boiler explosions had lately appeared, wherein discordant theories and opinions are offered on the action of steam in some anomalous cases of explosion, and which may justify reference to a few established facts and principles relating to the subject, in the hope in such cases of arriving at more settled views concerning causes and effects than appear to prevail at present among our most distinguished engineers. The author objected to the appeals made to Dr. Dalton's theory of atoms for explaining the nature of steam as an elastic force mechanically employed, since the law of definite proportions of Dalton had no reference to elastic vapours except as to the constituents of the liquors whence they arise. He then cited the fact that water, like steam, is an elastic body, and the pressure would therefore be of the same nature and force above and below the water-line in a boiler; but that explosions from fractures above or below that line would have different effects, owing to the amount of expansion of water and steam being so widely different when issuing from similar apertures and under the same pressure. Many obscure cases of explosion would be explained by the more or less rapid generation of steam issuing under those circumstances, as set forth in the paper. Thus free *space*, when suddenly and amply afforded, is to highly-heated water under great pressure nearly the same as fire is to gunpowder. And this will account for the most destructive cases of boiler explosions, whilst those of a more harmless nature show that the fractures were small at first and then gradually extended.

He also objected to the term "superheated steam," as being inapplicable to it in any state—because when steam is in contact with water it will be of the same temperature as the water; and if heated apart from the water, the same laws of expansion by heat apply to steam as to air, and neither can be superheated, though made very hot.

Again, steam can never be "mixed up with the water" in a boiler when both are under the same statical pressure, and the steam formed will rise into the chamber, so that the water will always be in contact with the boiler except when steam is drawn off. Still, in rapid escapes it may drive out water, and become entangled therewith, as in many explosions.

It having been shown that most if not all explosions are occasioned by simple steam-pressure acting on the weakest parts at first, and thence extending more or less rapidly, it would seem needless to seek for any other cause or force to account for them; yet in some cases the effects appear to imply a more sudden and violent action, like that of explosive compounds. In such instances, may they not arise from the actual decomposition of the water by heat alone? Although we have high authority (cited) against this, yet the author held it rash to conclude that water could not be resolved into its constituent gases by direct action of heat from the boiler upon water pressed into contact with the metal plates. It has been proved long since, that by heat, in the most intense form known to us—that of electricity—water is decomposed, and both of its constituent gases are liberated. Therefore, since no evidence has been adduced to show that this does not take place in any water when so confined and heated, the affirmative may at least be possible, and seems probable in some instances, as before named.

However, the author held it desirable that the question should, if possible, be set at rest by experiment; and to this end a method was suggested for putting the matter to a direct test; but he might not be able to make the experiment himself, and hoped it might be done by some one more competent to the task.

Electric Light.—A first experiment was made a short time since, of illuminating the famous Falls of Schaffhausen on the Rhine, 30 yards in height, by means of five electric lights: the effect is said to have been marvellous, especially when viewed through coloured glasses; the waves of the river resembled a sea of fire. The experiment was instituted at the request of the directors of the Swiss Railroad Company, who propose to organise a series of night-fêtes, of which this illumination will be the greatest attraction.—*Cosmos.*

NOTES ON ROMANESQUE ART IN THE SOUTH OF FRANCE.

By J. B. Waring.

(*Concluded from page* 117.)

I will now revert to a still earlier period of Christian art, as exemplified in the very important and interesting series of sarcophagi preserved in the Museum at Arles; dates are unfortunately wanting, and the names, which are Roman, though the persons were probably Gauls, afford no aid; they may however be generally assigned to between the third and sixth centuries: they are of the usual Roman sarcophagus shape, carved with subjects from the Old and New Testaments. Those most in vogue were the Saviour and the Apostles, sometimes in a continuous row, sometimes separated by columns. Once here, and once at Narbonne, we find trees instead of columns, very tastefully arranged, with birds in the foliage; the trees are apparently olive, the birds are doves. The miracles of the Saviour are also shown: these also are sometimes continuous, sometimes divided by colonettes: in the centre is usually a female figure with hands outstretched, intended no doubt for the Virgin Mary. From the Old Testament we have mostly Moses striking the Rock, Pharaoh in the Red Sea, Daniel in the Lion's den, and the Sacrifice of Isaac.

The tomb of the Labarum is carved with the Twelve Apostles without divisions, a line of cloud passes behind their heads with stars, and over each head a lion's paw holds a wreath or crown: in the centre is a large wreath containing the monogram of the Saviour resting on a cross, with two doves; two soldiers kneel at the foot of the cross, one on each side: over the Apostles are two genii or angels supporting circular medallions containing a male and female bust, and again two geni holding an oblong tablet without an inscription. Each angle terminates in a large mask, the facial line forming the angle. On one end is St. John baptising, and on the other Moses striking the Rock. This tomb is known locally as that of Constantine, it not improbably belonged to his family, and we may conclude it to be a work of the second half of the fourth century.

Sculpture is here seen founded on a good model, but somewhat rough of execution and heavy in proportion; the faces are singularly *à l'antique*, some of the Apostles are also of the Jewish cast of the best kind. No nimbi occur in these, or in any other example (except a very rough and unimportant one) in the collection. The dress consists of tunic and sandals; all the eyes have holes in the pupils, and generally also at the angle of the nose, to give expression. The whole character is strongly marked Roman; and though the heads are large, the hands clumsy, and the style conventional, yet there is a certain simplicity and nobleness about them by no means to be despised; some few of the heads are indeed first-rate, exhibiting such peculiarities as to lead one to conclude they are portraits At any rate, we find here a school of sculpture at an early Christian period; the best, I should say, then existing, and which ranks much above the stupid faces and lanky figures, the streaky hair and stiff drapery, the minute folds and jewelled borders, of sculptured art in the same district, which reached its bathos in the twelfth century. However tempting it is, I must not continue my meditation among the tombs, and will only add that at Narbonne, Toulouse, Lyons, Vienne, and Moissac we meet with numerous sarcophagi in which foliage and Christian emblems take the place of figures, which fell into disuse probably from want of good sculptors; and yet it is curious to see how closely the same model conch-shell, columns, and figures were followed at a later period, *i.e.*, the eleventh and twelfth centuries.

No one should leave Arles without paying a visit to the ruined abbey of Montmajour. Not to speak of its situation—perched on a rocky island as it were, rising from the well-watered plain, encircled with the olive and laurustinus, capped by the frowning tower of defence and refuge—the palatial ruins of the Italian style and the gray sombre Romanesque abbey, with its dark, vast, mysterious crypt and sculptured cloister, these alone would well repay the walk; but besides these are the rock-cut church, of a most primitive and remarkable type, and the mortuary chapel of the Holy Cross. The latter was built in the early part of the eleventh century, square on plan, with four semicircular apses and a western porch: the roof consists of a funnel-shaped dome: there are no openings for light; and when the concierge slams the door violently a whole park of artillery seems to be discharged, echoing faintly away into solemn silence. With the exception of the baptistery at Pisa, it produces the most extraordinary reverberations I ever heard; and if Mr. Roger Smith is ever in that part I recommend it to his notice. The masonry of this building is a perfect model of execution. Proceeding from this to the primitive church, we remark the rock honeycombed in all directions with open graves, the former occupants of which in their simple devotion sought to be interred as near as possible to the holy cross. Vain however was the hope! their resting-places are now bare, and their ashes are scattered to the wind; whilst the holy cross, if any true portion of it ever was there, served probably to light a fire in the revolutionary troubles of the eighteenth century. Descending by steps in the rock we enter the narrow passage of the original church, and a few steps bring us to an oblong space with circular roof cut in the rock; on one side is a plain window-opening, on the other two are stone graves, above which are cut two round-headed hollows or niches, now empty. Beyond this portion is the church, divided into two aisles by columns: on one side are three round-headed windows, on the rock side is a long low stone seat: there is a small semicircular apse to one aisle, and in the other is an altar in the wall with an open space beneath, probably a place of interment. Passing beyond this, through a passage barely large enough to admit one person, we come to four separate apartments, quite plain, with only one small light at the end of the passage, a curious rough stone chair by the window, two stone seats, and a so-called rock-cut bed. The round roof is formed by the rock itself, except in the chapel, where it is built: it is in the chapel also that the only ornament is found, its style being probably that of the tenth or eleventh century. Tradition ascribes this rock-cut church, with its graves, altars, confessionals, stone seats, and sleeping apartment, to the saints of the early church at Arles, and more especially to St. Cæsaire, bishop of Arles in the sixth century; nor do I think but that its existence may date from that epoch, although probably enlarged and ornamented at the time of the foundation of the great abbey in the early part of the eleventh century; for this curious monument of Christianity contains in itself on a small scale catacombs, chapel, hermitage, and place of refuge and defence,—the whole serving as a place of safety from the Goths and Saracens, who overran Arles in the seventh and eighth centuries, and bearing a marked analogy to the crypts or cubicula of the catacombs at Rome, which served as mortuary chapels and places of instruction for the catechumens, having stone benches for pupils and penitents, and stone chairs for teachers and confessors. The entire group of buildings here forms a most interesting study for the archæologist and architect; and I hope if any member of the Institute visit Arles he may be enabled to devote a few days to their pictorial and descriptive study.

Nor must we leave this district without saying a few words about the curious mediæval village or town of Les Baux. The traveller leaves Tarascon by omnibus for St. Remy, and must wend thence about ten miles *en voiture* to Les Baux. As regards picturesqueness, nothing can exceed it. A fortified town perched on the natural fortification of a rugged rock, and surrounded in all directions by upheaved granitic masses, it is the ideal of a robber knight's eyrie. Its value however to the antiquary has been much overrated, for except the ruined castle and hall, which appear to belong to the thirteenth century, most of the remains bearing any impress of architectural art are of the sixteenth century. The rock-cut houses, which may belong to any period, and are of the rudest arrangement, form the most curious and striking feature of the locality. They are however quite plain, with the exception of a few ruined chimney-pieces of the fourteenth and fifteenth centuries. A curious columbarium, or pigeon and dove cote—that necessary larder of live stock for the besieged—formed by numerous holes partly cut in the rock and partly built, still remains.

The only Romanesque remains at Nismes are to be found in the cathedral façade, and at a house on the Place: of the former very little remains, but what there is exhibits a close following of a Roman model, with frieze and pediment, not often seen even in this last home of Roman architecture. The frieze, very roughly executed, illustrates the first books of the Old Testament, commencing with the Serpent twined round the Tree of Knowledge; on one side Eve, whom he addresses, on the other Adam, who seeks to hide his nakedness: this combination of different points in one story is common with the early artists. The next subject is defaced. In the third, Adam and Eve are hiding themselves in trees, their busts only being seen, and the Lord addresses them. We then have the Expulsion; the Offerings of Cain and Abel; the Murder of Abel; Noah and the Ark; Lot and his Sons, and so on: all these subjects being continuous, as in the early Christian tombs. This fact, and the general character of the figures and drapery, lead me to conclude them to be of a very early date. We in England and the north of France have been perhaps too apt to fix on the first half of the eleventh century as constituting a clear line of demarcation in the history of architectural and sculptural art. It was so with us, no doubt, in a great measure, but in the south the course of art was more even; and in this particular example I think we may discern one of the earliest efforts of native artists at constituting a style founded on the models left them by the Romans, and which finally received a peculiar character from its combination with the semicircular arch, which we remark also on this façade on a small scale, and quite devoid of moulding or other ornament. The base of this cathedral appears to have had also a large frieze, on which some remains seem to indicate the form of the griffin, but all the rest of the building is too mutilated or altered to admit of investigation. What remains of the house, which was no doubt the bishop's palace, shows some very good sculpture, which is so essentially similar in style and subjects to certain parts of the church of St. Gilles (circa 1090) that we may ascribe it to the same period.

I am happy to say that M. Revoil, the government architect at Nismes, is engaged in publishing a work, with carefully measured drawings and with letterpress, on these monuments of Romanesque architecture in the south of France, which I venture to recommend to the notice of the Institute. No complicated system of construction is to be found in these buildings: the semicircular arch and dome in various combinations give, in this respect, its only claim to anything like science; and these are frequently heavy, and not well adjusted. Solidity and simplicity are however no bad substitutes for the more complicated and often less reliable systems of after times. The mouldings are generally Greco-Roman, combined with the hollow and torus common to Romanesque art everywhere; the ornaments of the mouldings are generally Roman,—the ovolo, leaf-fret, dentil, &c. The capitals of the columns, where not historiated, are mainly founded on a Corinthian or composite type, and the bases are usually Attic. The sculpture, as a rule, is stiff and lifeless, and the drapery, especially on the more richly-clad statues, of a thoroughly Byzantine character. The masonry is of medium-size blocks, slightly oblong, well worked, and carefully set in thin beds of mortar. No ornamental inlay is found, as at Auvergne and Lyons; no combination of brick and stone, as at Toulouse; and we may affirm that few more interesting classes of buildings are to be found for the architect and archæologist than these Romanesque churches of the south of France.

It is impossible to leave this district without putting in a word also for the grand remains of Roman architecture which ornament its soil. The noble walls of the theatre at Orange, the grand arcades of the arenas at Nismes and at Arles, the richly sculptured triumphal arches of St. Remy and Orange, the colossal aqueduct of the Pont du Gard, the mausoleums of St. Remy and Vienne, bear witness with a force stronger than the most powerful oratory to the manly genius and profound feeling for what is noble in architecture which characterised the old Roman race. However admirable, picturesque, and striking, however full of interest to the lover of Christian art, the most ambitious works of Mediæval Europe may be, yet, owing to the littleness and confusion of their parts, they appear as the work of pigmies in comparison with the grand simplicity and indestructible strength of these labours of the giants, against which the violence of man and the corrosive envy of time have expended themselves in vain.

On the direct route between Nismes and Toulouse there is not much Romanesque work. The interior of St. Paul, at Narbonne, exhibits in the sculpture of the capitals some curious applications of the palm combined with figure subjects, among which appear some very coarse and matter-of-fact representations of the vices of man. The exterior of this church is in the Pointed style, as are all the other principal monuments of this old but somewhat uninteresting city. The Museum however, besides the early Christian tombs before alluded to, contains some good bits of Romanesque art in the shape of capitals and fragments from buildings now destroyed; two richly-worked bronze censers; and a pastoral staff in ivory, very plain, ending in the usual serpent-headed crook, on which stands an angel regarding an empty chair or bishop's throne. The eighteenth century is also peculiarly well illustrated in this Museum, owing to the bequest of a local collector, who confined his attention almost entirely to that period.

From this point the traveller should by all means endeavour to visit Perpignan, with its Mozarabic and Spanish styles of architecture; and the adjacent church and cloister of St. Elne, so remarkable for the Egyptian character of several of its capitals, executed early in the eleventh century.

At Carcassonne, with the exception of some unimportant portions of the cathedral in the old town, everything is Mediæval. Carcassonne is M. Leduc's pet patient: he is trying to bring the old body to life, and rehabilitate its decayed and shrunken form; but although the doctor appears to have it all his own way, and to prescribe regardless of expense, I cannot say that the result is satisfactory. There is something ludicrous, to my mind, in this expensive and useless restoration of the old fortifications; nor can anyone approve of the wholesale manner in which old work is pulled down and carted away to make place for new. I must add that here, and in almost every case where this distinguished architect—to whose research, taste, and industry we are all so much indebted—has added designs of his own, whether in stone or metal, they appear to me to be of the most eccentric and emasculated character. The same rather anomalous result struck me also during a late tour through Germany, as regards Herr Heideloff's designs.

At Agen some good bits of Romanesque architecture remain in the choir and apse of the cathedral, but more interesting than these are some old arcaded streets which still exist in the centre of the town. The breadth of the pavement is about 25 feet, that of the street about 40, and the width between arches about 20 feet. The houses themselves are modernised or rebuilt, but the plan still holds good; and as the weather was very wet, and I had not an umbrella, my blessings fell on the manes of the departed municipal authorities. The same remark applies to the Bastide, or free-town of Libourne, near Bourdeaux, the great square of which measures about 180 feet each way: the passages are about 21 feet broad, the width between the arches about 14 feet: this example, though more complete, is ruined in effect by the lowness of pitch and narrowness between the piers of the arcade. The rest of the town, though of modern construction, still retains the right-angle arrangement of streets common to most of these (what may be termed) "model towns" of the fourteenth century.

But we are hastening on somewhat too fast, for we have got beyond Toulouse, a city which, besides its very remarkable Romanesque churches, possesses decidedly the most important and interesting museum of antiquities to be found in the south of France: these are deposited chiefly in the cloisters of the suppressed church of the Augustin Friars. The most numerous and varied section relates to Romanesque art, and we have here tombs, capitals, statues, and friezes, ranged round the open traceried cloister in a manner which recals pleasurably to mind the charms of the Campo Santo at Pisa. I do not mean to uphold the design or contour of these capitals and ornamental bands, as exhibiting any remarkable degree of study and refinement; but they have hardly received the attention they deserve,—their character is in a high degree rich, bold, and effective. The Museum contains numerous most interesting inscriptions; and it is to be remarked that in one of the oldest, that on the very curious slab tomb of St. Victor, at Marseilles (1048) we find the same style abbreviated, by placing small letters within large ones, as at the Abbey of Moissac, on the sculptured figure of Abbot Ansquetil (1100). This custom, with the use of Roman letters, continued down to a comparatively late period; and one of the earliest examples of the use of Gothic or German letters is to be seen on a tomb in the Museum, dated 1347. Two of the figures on the portal of an ancient church now destroyed—that of La Daurade, I believe—retain the sculptor's name: they are the best of the series, and the sculptor clearly was proud of his work: one has "Gilabertus me fecit;" the other, "Unincertus (?) me celavit Gilibertus." These statues are draped thoroughly in the rich Byzantine style, with small folds and gem-studded borders. Amongst the more fragile treasures of antiquity up-stairs—although it will not be shown without some trouble probably—the archæologist should not fail to see the so-called horn of Roland, which (if it really belonged to him) may be the one the hero died blowing, as he vainly sought with its notes to retrieve the rout of the Paladins. It appears to be the work of a European sculptor after the Byzantine manner, and was probably a tenure horn.

The most noble monument of Romanesque art in Toulouse—and indeed of the south of France—is the celebrated church of St. Sernin. It is built of brick and stone, as a three-aisled Latin cross basilica, with a semicircular apse and five apsidal chapels. There is a west entrance, with two north and two south ones. The general character is large and massive; the ornament pure and good Romanesque; and the brickwork very careful, judiciously relieved by courses and dressings of a warm-coloured stone. The whole is surmounted by the peculiarly fine brick tower, of five tiers of arcades, with which we are so familiar through engravings and photographs. The church is stated to have been finished and consecrated A.D. 1090. The best sculpture is to be found on the doorways, and I take the south porch (nave entrance) as an example. The cornice of the projecting wall shows the peculiar ornament and pateræ of Nismes Cathedral, combined with the brackets of Notre Dame du Port, at Clermont. The archway is semicircular, and in the centre is the Saviour in glory, attendant seraphim and angels, and the twelve apostles beneath. The angle corbels of doorway are formed by, David seated on a lion's back playing the viol, on one side; on the other, two men seated cross-legged, and caressing lions. The capitals of the columns are carved with subjects from the life of the Saviour, monsters, foliage, &c. There are two columns on each side; the mouldings are the plain hollow and round; the corbels of the cornice show in succession a monkey with a lion's head in his paws, a bunch of grapes, a lion, a monster vomiting his own legs, a young woman's head with wild dishevelled hair, a matron hooded, a goat, and an animal too much broken to be made out. It would be difficult to explain the two saints carved on each side of the portal with allegorical sculpture above and beneath. But however interesting the exterior may be, the interior is equally remarkable; and the marble slabs of the Saviour and the Apostles on the choir wall, stated to be saved from the old church built by Charlemagne, particularly merit notice. It is with great regret that an accident prevents my giving a more detailed description of this church. I understand that M. Leduc intends dedicating a monograph to it.

Toulouse is rich in buildings of the Mediæval and Renaissance periods. The brick towers of the churches of the Augustins (*musée*) and the Jacobins (*caserne*) are modelled on and rival the tower of St. Saturnin. The cathedral contains many portions of good Pointed architecture of various dates, and some good painted glass of the fifteenth and sixteenth centuries: the triforium is peculiarly rich and effective. Adjoining St. Saturnin is a large brick house of the fourteenth century, crenellated and arcaded, with angle turrets: it formerly stood within the walls which surrounded the church precincts, and is still in fair repair externally. The present Lycée retains many picturesque and remarkable Late-Pointed portions, while its Renaissance court is peculiarly striking. The "pestilent" Renaissance buildings (mostly mansions) of Toulouse are indeed, as a rule, very broadly designed, noble looking, and well calculated to satisfy the eye of every properly-educated architect.

There is not much Romanesque art, except at Moissac, on the direct route between Toulouse and Bordeaux, at which city the monuments of Mediæval architecture, civic and ecclesiastic, are very beautiful and interesting: the artist and architect will find plenty of work there.

But we have now passed almost beyond the boundaries of the south of France; and, however tempting the subject, I must leave for a future day the Romanesque buildings of the centre and the north, and conclude what I am afraid will already have been to many present "a twice-told tale."

Fire extinguished by Steam.—Some little time since a fire took place in the cellars of a candle manufacturer, situated on the Route d'Italie, outside the barrier. The engines were of but little value, and to subdue the flames they had recourse to a mode but little in use. The cellar doors and windows having been hermetically shut, steam was introduced, and the fire in a few moments extinguished. By this quick and effectual method, 200 tons of oil which the flames were on the point of reaching were preserved.—*Cosmos.*

INSTITUTION OF CIVIL ENGINEERS.

George P. Bidder, Esq., President, in the Chair.

Discussion upon Mr. W. H. Preece's paper "*On the Maintenance and Durability of Submarine Cables in Shallow Waters.*"*

It was observed that during the last two generations there had been three marked events in the engineering world,—Watt's introduction of the Steam Engine, which gave Power; the introduction of Railways, which supplied Locomotion; and the invention of the Electric Telegraph, which, as an instantaneous agent for transmitting thought, was fully as important as either of the others.

It was explained that with a view of limiting the paper, it had been impossible to notice the effect of temperature upon wires,—a frequent cause of serious error—the defects of stranded wires, testing under water, working damaged wires with single currents, the comparative advantages of screw and paddle-wheel steamers in laying and repairing cables, and particularly the improvements in the testing instruments introduced by Messrs. Siemens and Halske, of Berlin. It was thought that the chief points for discussion were,—the necessity of thoroughly surveying the route before laying a cable, the important question of the insulating medium, and of applying some exterior protecting coating, not only to cables intended for shallow water, but also for those to be laid in deep seas. The neglect of this latter precaution had, it was believed, been the cause of the recent failures in deep-sea cables, which had been found to be decayed and rotten when attempted to be lifted for repairs. The cable laid between Toulon and Algiers was believed to be nearly the true form for deep seas, and if combined with the Red Sea cable, the desired form would then almost be produced.

When the Channel Islands cable was laid, the electrical condition was considered to be most satisfactory, as the instruments acted with great facility, and with very low battery power. The selection of the route was not left entirely in the hands of the contractors, but was determined in concert with a government department. The shore ends of cables had generally been made too light, and in some cases, where rivers or bays had to be crossed, the plan had been adopted of laying the cable in a succession of tubes, connected together by universal joints.

One of the principal causes of the failure of telegraph cables was their not being thoroughly tested under water, until they were deposited in the ocean. When the Red Sea telegraph was laid, it proved, like most lines just completed, very successful. It was stated to have been worked from Alexandria to Aden, at the rate of ten words per minute, with double relay stations at Kossier and Suakin. There were a few embryo faults, but it was thought that it might have been worked successfully for a considerable time, if a permanent system of daily tests and of timely repairs had been established. There were other destroying agencies besides those which had been alluded to, such as excessive tropical heat, and the effect upon the cable of metallic veins at the bottom. The sections of the Red Sea cable had lasted altogether for nine months before the first fault occurred, having only given way the day before the Indian Extension was completed.

With regard to the government cable to be laid from Rangoon to Singapore, an opportunity had been afforded of carrying out a complete system of testing from the first. The old system was to test by the galvanometer, and to judge the condition of the line by the angle of deflection, and the battery power employed. This was not deemed satisfactory, for reasons which were explained; and instead, the method was adopted of comparing resistances. First, a constant unit of resistance had to be established, and the Messrs. Siemens used for that purpose the resistance of a column of pure mercury, one mètre in length and one millimètre in sectional area. This had the advantage of being easily reproduced, and was thought preferable to the plan adopted by the author, of taking the resistance of 1 mile of No. 16 copper wire, as the copper of commerce had been proved to vary in its conductivity between the limits of 100 and 7. Coils of resistance were next formed of German silver wire, representing respectively, units, tens, hundreds, thousands, tens of thousands, of units of resistance. By introducing these variable resistances into the three sides of a Wheatstone's Bridge, or Electric Balance, the resistance of the fourth side, which was the gutta-percha, or copper conductor of the cable under examination, could be ascertained with the utmost certainty, the limit of error not exceeding practically one in one thousand. Another feature of this method was, that the time during which the electric current was allowed to act before the observation was taken, was noticed. It had been discovered that inductive tension followed the same simple law of Ohm as the electric current itself, in passing from the conductor through the insulated covering, and admitted therefore of being subjected to the same precise methods of measurement. Although this system of testing cables had not been long in use, yet resistance coils had been employed for determining the position of faults in subterranean lines ever since the year 1849. In the case of the Rangoon cable a complete record was obtained of the copper and gutta-percha resistances of each mile of cable, so that when the core was joined together it was possible to detect the slightest defect, which, if allowed to pass, might afterwards develope itself into a fault. Moreover, in laying the cable, or afterwards, any decrease of the insulation was at once known. It had been originally intended that the Rangoon cable should never leave the water, that it should be kept in tanks during the process of manufacture, and be payed out from tanks into the sea. As however the tanks could not bear the great pressure, the cable became exposed to atmospheric influences. It was soon observed that there was a decrease of insulation, indicating a considerable increase of temperature. Subsequently, this became so great that it was necessary to test the temperature of the coil of cable in every part. For this purpose a peculiar thermometer was used, constructed upon the principle of the resistance of copper wire to the electric current, or tube of metal. In coiling the cable on board several of these thermometers were inserted at different layers of the coil. When tested, after being on board only one week, it was discovered that a spontaneous generation of heat had taken place, and that the heat developed itself unequally throughout the mass, the highest temperature being about 3 feet below the upper surface of the coil. A large quantity of water, at a temperature of 42° Fahr. was poured upon the cable, and this was observed to issue from the bottom of the hold at 72° Fahr. This occurrence seemed to show that other cables, more particularly the Atlantic cable, which had been coiled on board wet, might have been ruined from the same cause. If the heating had been allowed to continue a few days longer, the gutta-percha would have been softened, and the copper conductor would have become eccentric to the insulating material. It was considered probable that this generation of heat was due to fermentation of the hemp covering, whilst it had also been attributed simply to the rusting of the iron.

---

* See Journal *ante*, page 25.

With regard to the construction of cables, it was considered that a metallic covering must be adopted, as there were cases were hemp-covered cables had been completely destroyed by marine animals; but that the external iron covering should be protected against the action of the water. In reference to the insulating material, gutta-percha had several disadvantages. It was readily softened by heat, was liable to contain cavities, and was affected chemically by every current that passed into it. India-rubber possessed a much higher resistance to electricity; and certain compounds of that material had also valuable properties.

It was admitted that the only depths considered to be of primary consequence in the early nautical surveys were those under 7 fathoms, the depth at which a large line-of-battle-ship might strike the bottom. It was maintained that iron should never be employed as a covering for submarine cables. Such a defence should be composed of copper, or of some metal, or other substance, that would not oxydise, and that would receive a gradual submarine deposit of a calcareous nature, affording a permanent protection against damage or decay. But, as far as experience had shown, it appeared that in the deep ocean scarcely more than the insulating covering was generally required.

It was remarked that submarine cables for shallow waters might be comprised under four classes:—1. The hempen cable; 2. Galvanised iron cable; 3. Unprotected iron cable; and, 4. Iron cable with some protecting covering. With respect to the first, there were mechanical defects sufficient to condemn its use, as the action of abrasion against the tide and rocks would cause it to be destroyed in a few days. On the other hand, galvanised iron cables, of which there were many hundred miles laid from the English coast, seemed to be very durable when buried in mud or sand; but wherever they were exposed to the free action of the tide, corrosion commenced. They however possessed a durability of about three years beyond unprotected iron cables; but after that time the zinc generally disappeared, and all cables were alike acted upon by the sea water, whether originally galvanised or not. This corrosion was conjectured to result from the cable lying upon protruding veins of copper ore, or other material which was electro-negative with respect to iron. The first cable laid between Hurst Castle and the Isle of Wight, five or six years since, became so deeply corroded in eighteen months that it was broken by a ship's anchor. This was replaced by a smaller cable, which did not last a year, and subsequently by a third of stronger construction, and that was now being superseded by a fourth cable. Therefore, three cables had been already destroyed, partly by ships' anchors, and partly by corrosion. It was believed that sea water alone was not sufficient to produce this destructive action upon iron. A cable laid from Whitehaven to the Isle of Man, was coated with a serving of jute saturated with common asphalte. The process was inexpensive, and appeared calculated to last for an indefinite period.

The failures of the Atlantic and of the Red Sea cables certainly demanded most serious consideration. That some mischance should happen to the Atlantic cable was not surprising, when the limited experience then obtained in submarine telegraphy in deep water was taken into account. But in the case of the Red Sea cable there was no excuse for using unprotected iron wire, scarcely larger than bell wire, for the covering, as there had then been abundant experience to prove that after being only a few months in the sea it would become so rusted that should any repairs be necessary, it would not be possible to lift the cable to the surface. Similarly, the cable about to be sent to Rangoon would not be fit for use for more than three or four years, under the most favourable circumstances; and if repairs were required the cable would be found to be so much decayed that it would not be able to be raised. It was to be regretted that a cable designed to be laid from Falmouth to Gibraltar should have its destination changed to a much warmer climate, because the electrical conductivity of gutta-percha was greatly increased or its insulation was impaired by heat.

In reference to the Red Sea telegraph, it was remarked that before the form of cable was determined upon, a specimen of the cable proposed to be adopted was submitted to several eminent scientific men, who generally concurred in the propriety of using it, and on no occasion were the directors dissuaded from having a cable covered with iron wire.

In reply it was argued, that at the time the Red Sea cable was designed, so many instances had occurred of the oxidation of the iron covering of cables, and their decay was so much a matter of notoriety, that provision ought to have been made to protect the iron from the destructive action of the sea water.

In selecting a route for submarine telegraph lines, it was thought that deep water should be avoided wherever that was possible, even if a considerable detour had to be made. In a depth of 100 fathoms a cable was beyond the reach of attrition, and was as little likely to be injured as when laid at a depth of 200 or 300 fathoms; whilst it could be repaired almost as easily as if it lay in water 30 or 40 fathoms deep. The nature of the bottom was most important, as where rough ground and rocks existed the cable could not be grappled. To ascertain this correctly, the use of the sounding lead alone was not sufficient; a mushroom anchor, which would bring up a bucketful of the surface material, and occasionally deep-pronged grapnels, ought to be employed. The line should be divided into short sections, of say 100 miles in length; for although it might be possible to "work" through 500 or 1000 miles, yet when one section was damaged the consequences were more serious. It was believed that the Red Sea and Indian telegraph cables might have been laid where they could easily have been grappled, and lifted for repairs; and that in the line from Suez to India there would not have been any difficulty in dividing it into sections of 50 miles each, throughout nearly the whole distance.

With regard to the maintenance and durability of shoal-water cables, it was remarked that there were two schools of engineers, one adopting comparatively light cables, the other laying them as heavy as possible. The earliest submarine cables between Dover and Calais, Dover and Ostend, the Magnetic Company's lines to Ireland, as well as several others, were all strong cables, containing several conducting wires, covered with a thick serving of hemp, and over all massive iron wires of large gauge. These had been singularly fortunate. It was true that some of them had been injured by ships' anchors, but those occurrences were rare, and the cables never suffered from "abrasion," or from being "washed away by the sea," causes which seemed to have been so fatal to the Channel Islands telegraph. The new system of laying light cables in shoal water was first adopted by the Electric Telegraph Company in their lines from Orfordness to the Hague, where, instead of laying one strong heavy iron cable, four comparatively light cables, each with one conductor only, were laid across the North Sea, on the principle that the chances were against all the four being broken at the same time. That experiment, which had also been adopted by the same company between Dublin and Holyhead, could not apparently have been satisfactory, judging from the high annual cost stated for repairs, and from the fact that a heavy cable had been recently laid by that company from Dunwich to Zandvoort, in Holland. A somewhat similar plan had been pursued in the Channel Islands and the Red Sea lines, for the latter was laid to a great extent in shoal water. With these exceptions all the shoal-water lines had been strong cables, and there were many in existence in different parts of the world which had never required the most trifling expenditure for repairs since the date of their submersion. Two of these belonging to the Magnetic Company, were necessarily laid on a rocky bottom, subject to the action of strong currents, but they were laid with sufficient slack to meet any irregularities in the bed of the sea. The heavy cables laid in 1854 between Spezzia and Corsica, and across the Straits of Bonifacio, passing over depths of between 700 or 800 fathoms, and crossing several coral reefs, had worked well and continuously. The Submarine Company's line from St. Catherine's, in Jersey, to Pirhou, on the coast of Normandy, although not much larger in dimensions than the Channel Islands cable, had never given any trouble since it was laid. Therefore the casulties which had occurred could not be considered as inherent and of necessity belonging to shoal-water cables, but must have arisen from the cables themselves not being suited to the work.

It was stated that the Red Sea telegraph was divided into six sections,—three in the Red Sea, Suez to Kossier, 254 knots, Kossier to Suakin, 475 knots, and Suakin to Aden, 630 knots, or in all 1359 knots of direct distance; and three in the Indian Ocean, Aden to the Kooria-Mooria Islands, 716 knots, Kooria-Mooria to Muscat, 486 knots, and Muscat to Kurrachee, 481 knots, or in all 1683 knots; making the total length of the two lines 3042 knots. Messages had been transmitted between Suez and Aden for about nine months, and separate sections of this line had been worked for eighteen months. It was also mentioned that the line had been worked from Aden to Kurrachee by means of translation at very good speed; but that the whole distance from Suez to Kurrachee had never been worked throughout. The cable had been under-run and examined for many hundred miles, and was certainly not corroded to the extent which might be imagined. As a general rule the strength of the cable had not been diminished one-tenth by corrosion, after being submerged a year.

With regard to the Rangoon cable, originally intended to be laid from Falmouth to Gibraltar, and therefore designed for deep water, it had an outside covering of hemp and steel, and possessed, it was asserted, a greater tensile strength in proportion to its weight in water than other cables previously tested. The cable laid from Toulon to Algiers was constructed upon the same principle, and upon a "kink" occurring, it was successfully hauled back for 3 miles out of water 1600 fathoms in depth.

The old surveys and soundings might have been sufficient for the purposes of navigation, but they were not of that complete character to render the submergence of a submarine telegraph cable a safe operation. From the records of such surveys it appeared that the mean interval of the soundings in deep water was 20 miles. Now, on the Valentia side of the Atlantic, there was ascertained to be a dip of 7200 feet in 10 miles, and near the east coast of Greenland of 3468 feet in 3 miles. It was evident therefore that very inaccurate estimates of depth might be arrived at if the observations were only taken at intervals of 20 miles. The recent examination of the proposed line from this country to Labrador, showed that near Iceland there was a series of abrupt elevations and depressions at short intervals, producing a saw-like disposition of the surface, which was composed of volcanic rock that never lost its abrasive character or the angularity of its particles.

Hitherto gutta-percha had been considered as the sole material for insulation; but recent experiments had shown that india-rubber possessed a high insulating power, and specific inductive capacity, with great flexibility and elasticity. Its durability could only be tested by time. As a proof of its qualifications in that respect, a specimen of wire insulated with india-rubber was exhibited which had been used experimentally between H.M.S. Pique and Blake in the year 1845, and across Portsmouth harbour in the following year; also a large coil of wire so insulated. In these cases the india-rubber had remained perfectly durable and hard. The failures of the Atlantic, the Red Sea, and the Rangoon cables, were believed to be attributable to their want of proper insulation. This was owing to the porosity of gutta-percha, which admitted a slow transudation of fluids through its mass, to such an extent that when made into bottles or other vessels they could not be used for holding chemical fluids.

There were already about thirty undertakings in submarine telegraphy, owning in the aggregate nearly 3000 miles of cables, a large proportion of which had been completed and been at work for many years, and some of which, though more recent, had been successfully laid in very deep water. These cables had hitherto remained in almost perfect working order, having cost an inconsiderable percentage in maintenance since submersion. This was most probably due to the adoption of the model of the first successful cable laid between Dover and Calais in the year 1851, which was protected by thick iron wires of the best quality, for the cables between Portpatrick and Donaghadee, Portpatrick and Carrickfergus, Dover and Ostend, and other places. The failure of the Irish lines of the Electric Telegraph Company, and of the galvanised iron cable from Orfordness to the Hague, were believed to be due to changes in the character of the cables, made too much for the sake of change, having reference to anchorage and other risks of breakage; as they were all cables of small dimensions and of limited strength. In shallow waters, the thickness and strength of the cable ought to be limited only by the ability of the machinery to lay it, and the power of the projectors to pay for it.

In reference to the cables between England and Holland, it was remarked that these were the first long cables; and it was not then possible to lay a cable 100 miles in length equal in weight to that between Dover and Calais, even if it had been thought desirable. That was not however the only reason for the adoption of four light cables. It was considered that there would be less risk in laying them, that it was improbable all of them would be injured simultaneously, and that when damaged, they could be more easily and cheaply repaired and renewed; and it was thought to be still an open question whether a more economical method of insuring a constant communication could be adopted.

In deep-sea cables there had been little else than failures, from causes, it was thought, rather within the scope of the moralist and the man of the world, than the man of science. The details of the Atlantic cable were arranged before anything was practically known about deep-sea cables; but it was designed upon enlightened principles, and perhaps could be laid at the present day with the probability of enduring, although the conductor, owing to its small size, would not enable the same rate of working to be attained that was now possible. Great mistakes were however made in organising the undertaking—the radical fault being the precipitate manner in which the contracts were let—precluding any preliminary practical experiments. The laying of the cable ought also to have been postponed. The Red Sea cable was another instance in which a disastrous waste of public money had its origin in causes entirely apart from scientific difficulties. After the concession had been purchased, it was found that owing to a complication of arrangements, the directors had also acquired an engineer and a contractor; that practically the form of the cable was decided upon; and that little remained for the board to do but to pay. Although at the instance of Lord Stanley the specimen of the proposed Red Sea cable had been submitted to several scientific authorities, this had not been done until the form had been so far decided upon, that it had become a foregone conclusion, as the contract for its manufacture had actually been entered into. The Blue Book showed that there had been previous dealings between the engineer and the contractor; the concession for an important portion of the route—namely, that between Constantinople and Alexandria, had been already sold to the contractor for the Red Sea cable, and thus it was considered imperative to give the latter contract to Messrs. Newall and Co., at a higer price, as they alone could promise a direct through communication with England by a stated time. The contract was wrong in principle; one great vice being that it was taken for a lump sum, thereby offering a premium upon the chances of saving some part of the slack, or surplus cable. Hence the fractures, which were asserted to have been occasioned by the tightness with which the cable was laid. If properly investigated, it would be found that submarine telegraphy was not an enterprise involving so much of mystery or of risk as had been supposed. With regard to the Rangoon cable, it was thought if the wires surrounding the core had been saturated with tar, as had always been done in the case of former cables, the heating would not have taken place.

Within the last few months the cable belonging to the Mediterranean Company, between the Island of Sardinia and the coast of Africa, which was laid in the year 1857, having failed, it became necessary to repair it. Tests showed that there were some bad faults about 40 miles from Sardinia, and that within 5 miles of the coast of Africa the cable was broken. This break, and another 2 miles further out, were believed to have been caused by the trawls of coral fishers, after the outer wires had been corroded. In fact the whole of the deep-sea cable near Africa was found to be corroded, whilst the thicker shore-end was not injured by corrosion. On picking up the cable, beginning at the island of Sardinia, the first 39 miles were found to be as sound as when laid. But at this point a change occurred in the character of the bottom, and a short distance further out the cable was broken from corrosion as it lay at the bottom, at a depth of 1200 fathoms. Specimens of the rust or bark from the cable had been analysed, but it did not appear that the corrosion was due to the decomposition of the animal matter adhering to the cable. The cause of the fracture of the Bona cable in deep water was attributed to its having been laid too tight, so that when the outside iron wires were decayed, the elasticity of the cable caused it to part. With respect to the remedies for these disasters, the first appeared to be the employment of larger gauge wire; but for long deep-sea lines it would be impossible to adopt heavy wire coverings. A second remedy was coating the external wires with some bituminous composition which would not injure the gutta-percha by heat when applied, and was not too expensive in its application. It had also been proposed to make careful soundings of the bottom along the route which the cable was to be laid; but until the nature of the bottom which caused corrosion was better known, this remedy could not be relied on with safety. It was submitted that the adoption of a light cable not covered by iron wire might possiby be advantageous; for although small iron-covered cables had failed, there was no evidence to show that cables unprotected by iron wire would also fail. When this subject was discussed at the Institution in the year 1858, corrosion was not mentioned as a source of danger to cables. At that time the Malta and Corfu cable, which was somewhat similar in construction to the Atlantic cable, had been in operation for eighteen months; and the Red Sea cable was then designed, as well as the Levant cable, both being nearly alike, and the latter chiefly belonging to Messrs. Newall and Co. It was singular that the Levant cable had proved to be an exception to the general law of destruction; inasmuch as all the sections which were laid still remained in working order—including the lengths between the Dardanelles and Scio, Scio and Candia, Scio and Syra, Scio and Smyrna, and Syra and Athens, in all about 600 miles. On the other hand, since 1858 many instances of corrosion had occurred in the Atlantic, the Black Sea, the Mediterranean, and the Red Sea, and also near the English coasts.

Passing to the electrical part of the paper, it was believed that the charge was inversely proportional to the logarithm of the ratios of the external and internal diameters of the gutta-percha covering, and that it was not proportional to the surface of the copper conductor. Where the resistance of the cable formed a large part of the circuit, the deflections given by the water current would not be of much use in determining the distance of the fault, or the amount of copper which was bare. The gas currents which had been alluded to were commonly known as polarisation. The practice of expressing the resistance of gutta-percha by units was introduced by Prof. W. Thomson in 1857, at the meeting of the British Association in Dublin. Mr. Jenkin, in 1859, at the meeting of the British Association at Aberdeen, gave the insulation of the Red Sea cable in terms of the specific resistance of gutta-percha, which corresponded to a resistance per knot of 94 millions of Siemens' units at 60° Fahr. At the same time temperature curves derived from actual experiment were given, and the great influence of continued electrification was mentioned. Complete details of all these experiments were presented to the Royal Society in 1860. Although so much attention had been paid to the testing of the Red Sea cable, it appeared that it had not been immersed in water during the tests; and unless that were done faults could not be detected. This omission probably arose from fear of oxidation to the outer wires, but that was scarcely a sufficient excuse, as the cable should have been so made as not to be liable to be injured by such a cause.

With regard to the question of units, it was urged that it was desirable to introduce a system which should be universally adopted. The system of units first proposed by Weber in Germany, in 1851, and shortly afterwards by Prof. W. Thomson in England, was founded upon the relation between electricity and mechanical effect, and did not depend upon an arbitrary assumption of some one quantity of the same nature as the thing to be measured. It was thus possible to express electrical values in units depending directly upon the absolute units of force; and not only could electrical resistance be so expressed, but also the strength of a current, the electromotive force of a battery, and the quantity of electricity.

The results were then given of a series of experiments undertaken to show that injuries to the core of a submarine cable, caused by accidents during the manufacture, might be temporarily repaired so as to escape detection, by the "serving" being saturated with tar and tallow, which was an insulating mixture. Other experiments were also made with a view to ascertain what degree of heat would affect the core, when it appeared that no fear need be entertained so long as the temperature did not exceed 100° Fahr.

In reply, a hope was expressed that the observations which had been made during this discussion would have the effect of inducing the Admiralty authorities to give instructions to their hydrographers that in as carefully depicted as the surface of the land was on geological maps. future surveys the bottom of the sea surrounding these islands should be The Channel Islands cable had been laid with such an amount of tension that it was necessarily subject to abrasion; and when its strength was reduced by some of the wires being chafed, the cable was readily broken asunder. This fact seemed to show that in shallow waters cables should be laid as slack as possible, consistent with avoiding "kinks." The failures of submarine cables in shallow water did not appear to be due so much to inherent defects in the cables themselves, as to the localities in which they were placed. In proof of this it was stated, that although the Portpatrick and Donaghadee cable, which had been submerged eight years, had never been damaged, yet the Dover and Calais, the Dover and Ostend, and other cables equally as strong, had been broken. Then again, the cable connecting Jersey with Pirhou, on the coast of France, which was laid in the latter part of 1859, although it had remained in good working order, while the Channel Islands cable had been broken in five or six places in the same time, yet a similar description of cable, 5 or 6 miles in length, laid off Alderney, when taken up a short time ago was found to be in a very bad condition. Again, although the Hague cables had given a great deal of trouble, a similar cable, laid in 1857 on the coast of Norway, had remained in good working order. The decay of cables from corrosion was due to three causes, —1st, to simple oxidation from water running over the cable; 2nd, to the cable lying upon a metallic surface; and 3rd, to the formation of vegetation upon the cable. From the evidence already obtained it would seem to be essential in the submersion of future cables that some means should be adopted to prevent the rapid deterioration and decay of cables at present experienced.

The credit of the invention of resistance coils was attributed to Prof. Wheatstone, who in 1843 described them in a paper read before the Royal Society. Their introduction and useful application in England was believed to be due to Mr. Cromwell Varley; and they had been used by the Electric Telegraph Company some time before the year 1852. It frequently happened in repairing a cable, that on the surface of the gutta-percha there was found a small lump, a little hole, or a piece blown out, as if burnt by a flash of lightning. These effects had been, erroneously it was maintained, attributed to lightning. On the other hand, it was contended that the great enemy in the working of a cable was ozone. When the smallest puncture admitted the least drop of water in connection with the cable, the decomposition which took place generated ozone, which was known to attack in a rapid manner all inorganic substances like india-rubber or gutta-percha. As to the comparative merits of india-rubber and gutta-percha as insulating materials, the electrical qualities of the former had been proved to be far superior to the other; and the only thing wanting to justify the use of india-rubber for long deep-sea cables was positive proof of its durability. Now the submarine cables laid in 1852 for connecting Hampshire with Hurst Castle, and also crossing the Yarmouth river in the Isle of Wight, were coated with india-rubber, which was now as durable and as good as when first laid down. There was no reason why cables should not be taken up, examined, and repaired, periodically; and it was believed that submarine telegraphy would shortly have arrived at that state when it would be possible to preserve the communication uninjured for an almost indefinite period.

If the paper and the discussion had exhibited the subject as one of national importance, it had also shown it to be a branch of the profession the practice of which up to the present time had been signally unsuccessful. Upwards of 9000 miles of submarine telegraph cable had been laid down, of which not more than 3000 miles could be said to be in working order; so that there were 6000 miles which were almost utterly useless. This result showed conclusively that there was either a lamentable want of knowledge on the subject, or some radical practical error, which should be carefully inquired into with a view of applying a remedy. The present deplorable state of submarine telegraphy was endeavoured to be accounted for in Blue Books and other published documents by reference to causes which practical men could not admit; and the conviction which forced itself upon the minds of unprejudiced men was, that the obstacles to success had been more of a moral than of a mechanical nature.

It was hoped that the promised Report of the Government Commission on Submarine Cables would give facts which would either confirm this opinion or dispel such an impression. It was understood that the report would go fully into the questions of the methods of insulation and of testing cables. These had been already brought within the province of mathematical certainty, yet the application of the results had not been satisfactory; and patents were even recently taken out, as if for the purpose of adding difficulties to processes which were already sufficiently complex. Patents had in fact proved the curse of telegraphy, for scarcely was the ink of the agreement for the purchase of one patent dry, before another was offered which was warranted to supersede all that had been previously accomplished.

The first considerable failure of a submarine cable was that of the Atlantic Telegraph Company. It would be remembered, that in a discussion before the Institution of Civil Engineers it had been strongly urged that the cable should be tested during its manufacture, and subsequently that it should not be laid until it had been tested under water, as nearly as possible under the conditions to which it would be subjected when it was laid in the sea. In violation of all these precautions, the cable was laid, with the conviction of its not being in a perfect state; a capital of upwards of £300,000 was sunk, and the cause of electric telegraphy was seriously jeopardised. It must be admitted, that even if the cable had been perfect when it was submerged, there were natural causes in operation which would probably have destroyed its conductibility in little more than twelve months; this however could not excuse the recklessness with which so large a capital was risked without adequate precautions.

Several of the deep-sea Mediterranean lines had failed from mechanical causes, some of which had been foretold before the submersion of the cables had been attempted. This demonstrated the necessity for more careful and accurate surveys of the bottom of the ocean to the depth of 500 or 600 fathoms on the lines where cables were to be laid; beyond that depth it might be assumed that there would be little, if any, mechanical action. Corrosion would take place, but commercially that could be provided for by a fund for replacing the cables when they became unserviceable.

The last great failure which had attracted public attention was that of the Red Sea telegraph. This assumed more than ordinary importance, because the country was under engagement to pay about £36,000 per annum as guaranteed interest upon an outlay which, up to the present time, was utterly useless, and which did not appear to afford much hope of ever being otherwise. The history of this undertaking, as far as it had been made public, was given in the parliamentary papers on "Telegraphic Communication in the Mediterranean, and with India" (1859 and 1860). These published documents only would be quoted from —and, without entering into all the minute details, it would suffice to lay before the meeting the broad facts, whence it would be seen that moral causes had entered largely into the fate of this unfortunate undertaking.

It had been stated that the sanction of the late Mr. Robert Stephenson had been obtained as to the form of the Red Sea cable. This was probable, as he was always ready to give advice to whoever asked it; but when responsibility was attempted to be fixed upon him, it became necessary to ascertain to what extent his sanction had been given. Did the gentlemen who consulted Mr. Stephenson as to the construction of the cable inform him who was to be the contractor;—did they communicate to him the conditions of the contract, or the restrictions under which it was to be carried out? If they did not do so, his opinion as to the mere form of a bit of cable, given probably in the free communication of one gentleman to another, and not as a professional opinion, with all the circumstances of the case before him, should not be made use of to shift the onus of failure from the living to the dead.

Now as to some of the dry facts relative to the Red Sea cable. The letter of Messrs. Glass and Elliot, of June 26th, 1858, addressed to the Lords Commissioners of the Treasury, said—

"We beg most respectfully to address your lordships on the subject of the proposed line of telegraph to India, by way of the Red Sea, which project is now under the consideration of your lordships at the instance of the Red Sea Telegraph Company. That your lordships may be fully informed of the circumstances which have led to this communication, it becomes necessary to lay before you the following brief history in connection with the progress of the undertaking, and our connection with the same.

"In the year 1855 application was made to us by Mr. Lionel Gisborne, who represented himself as acting for and under the authority of Her Majesty's government, for information to enable him to prepare estimates for the carrying out of a telegraphic line to the East; and on his assurance that we should be placed in a position to tender for the execution of the work, upon his completing certain arrangements with the Turkish government, we provided the necessary information, accompanied with many specimens of submarine cables best suited for the contemplated line, with estimates, &c., upon which Mr. Gisborne proceeded to Constantinople, and obtained the necessary firman from the Sultan to lay down the line now under consideration. Shortly after his return to this country, these concessions were placed at the disposal of a body of gentlemen, who formed themselves into a company (the Red Sea Telegraph Company), for the purpose of carrying out the lines under the concessions obtained by Mr. Gisborne. In the month of August last the directors called upon us to assist them with information, and afterwards to tender for the execution of the whole or one-half the line; which we did, and a prospectus was issued founded on this estimate, but an insufficient amount of capital was subscribed, caused by certain statements in the public newspapers to the effect that it was impossible to lay a cable in the Red Sea, from its great depth and other causes. In this state of things we suggested the propriety of an application to Her Majesty's government to cause a survey to be made, with a view of testing the truth of these statements: this course was adopted, and the Cyclops was ordered on the expedition, and instructions, forwarded on our suggestion to the Admiralty through the hydrographer, were sent out to the officer in command of the Cyclops, and the result having been highly satisfactory, a further attempt was then made by the directors to carry out the line; hence the proposal now under the consideration of your lordships. The undertaking having thus far proceeded, it was found that the agreement between Mr. Gisborne and the directors of the Red Sea Telegraph Company had in the meantime lapsed by a few days; and on being called upon by the company to renew the same, he consented, but insisted, as we have been informed, that in addition to the sum of £15,000 agreed to be paid to him in consideration for the concessions, that he should be appointed engineer to the company, and that the whole of the work should be given to Messrs. Newall and Company, without tender; Messrs. Newall and Company having become interested with him in the concessions, and he was bound to them accordingly. The directors have felt themselves constrained, under the peculiar circumstances of the case, to submit to the terms imposed by Mr. Gisborne; and a conditional contract has been entered into with Messrs. Newall and Company, approved by Mr. Gisborne, to carry out the works for the sum of £650,000, or thereabouts. The directors having given us an opportunity of seeing these estimates, we are in a position to inform your lordships that we are prepared to execute similar work for £100,000 less than that amount. Should your lordships find on inquiry that our statements are correct, we feel sure that your lordships will not, under such circumstances, sanction the application of public money to this purpose, for the private gains of individuals to the prejudice of the public."

Upon this there followed a Treasury Minute, dated Aug. 4, 1858:—

"Inform Messrs. Glass, Elliot, and Company, that my lords have made an arrangement with the Red Sea Telegraph Company, by which, on certain conditions, a guarantee on the part of Her Majesty's government is granted to that company.

It is one of the conditions in the arrangement that the line of telegraph shall be laid down on the responsibility of the company; my lords do not propose to interfere in the selection of the parties who are to execute the work, further than to see that its proper execution is sufficiently secured. My lords have no doubt the company will adopt the proper means of procuring contracts for the execution of the works on the best terms, and can only refer Messrs. Glass, Elliot, and Company, to the directors of the company."

The first of these documents proceeded from rival manufacturers, but no public explanation had ever been offered of the facts alleged.

On the 27th of August, 1858, the chairman of the board of the Red Sea Telegraph Company, in a letter to the Treasury, said—"As regards the selection of contractors, they (the directors) beg to state that the choice lay between two firms, and that, in a matter of so much importance, and with so limited a number of competitors, it appeared to them that the early and satisfactory completion of the enterprise would be most effectually promoted by the selection of the contractors who combined the highest reputation with the greatest experience in laying submarine cables. The reputation of Messrs. Newall and Co. stood preeminent, and they had already succeeded in laying several telegraphic lines."

Inclosed in this letter was "A memorandum of agreement made and entered into between the Red Sea and India Telegraph Company, of the one part, and Robert Stirling Newall, Charles Liddell, and Lewis Dunbar Brodie Gordon, all of Abingdon-street, Westminster, trading under the firm of Newall and Co., of the other part," covenanting that "the said Messrs. Newall and Co. shall manufacture and lay down *the cable* from Suez to Aden, and, if the board should require it, and announce their desire to that effect, within four weeks from the date hereof (left blank in the Blue Book), from Aden to Kurrachee, at their own risk and responsibility, and deliver the cable complete and in full working order and condition for the sum following, viz.:—From Suez to Aden for the sum of £225,000; from Aden to Kurrachee for the additional sum of £246,425. The board are to have the right of inspecting the cable and materials during manufacture and while laying, by their own members and by their officers and persons appointed by them, in such manner and at such times as they may think fit."

On the 23rd September, 1858, Mr. J. Cosmo Melvill wrote:—

"With regard to the proposed arrangements for executing the work, Lord Stanley is not aware of the reasons which induced the directors of the (Red Sea) Telegraph Company to enter into a contract for the cable without resorting to the system of competition; and he does not perceive why that principle could not have been advantageously applied in this case, or why both the firms engaged in the manufacture of the cable which the directors appear to have taken for their model, should not have had the opportunity of making a tender.

With regard to the description of cable which has been fixed upon, Lord Stanley is inclined to urge that every precaution should be taken to secure the best that can be devised for the purpose. It is well known that grave doubts are entertained by some authorities as to whether the Atlantic cable meets all the requirements of a submarine telegraph work, and he would suggest therefore the desirableness of obtaining the concurrent opinion of two or more eminent authorities upon the subject, before making final arrangements.

Having perused the proposed agreement with the contractors, the only observations with regard to its terms which I am desired to make are, that it would be desirable to modify the first clause so as to oblige the contractors to keep *the cable* in working order for one month at least from the date of the first message passing through it; and that clause 4 should be made quite clear upon the power of the Telegraph Company to test as well as inspect the cable and its component parts in all stages of its manufacture."

This letter must be borne in mind, as it related to the important points of the contract being given without competition, the form of the cable —referring to the "grave doubts" entertained with respect to the Atlantic cable, which at that period had virtually failed,—and the obligation to be imposed on the contractor to keep *the cable* in working order for one month at least from the date of the first message passing through it, the original proposed period of maintenance being only ten days.

It should be observed that up to this point no mention was made of the testing, or of the reception of "sections" of the cable; but "the cable"—meaning the whole extent of the cable from Suez to Kurrachee —was evidently intended by the government and by the Red Sea Telegraph Company.

In the letter of the 28th of September, 1858, from the chairman of the Red Sea Telegraph Company to the Treasury, after repeating the former reasons for giving the contract to Messrs. Newall and Co., it was stated:—"But it was also supported by the consideration that the firman from the Turkish authorities, which was the basis of their operations, would lapse unless the telegraph was established between Constantinople and Alexandria before the end of the present year (1858); and that Messrs. Newall and Co. engaged, on receiving the Red Sea contract, to complete that telegraphic communication from their own resources in time to save the Turkish concessions."

Now it must be observed that up to the present time (1861) no communication between Constantinople and Alexandria had ever been made; yet that was one of the chief reasons for not submitting the contract to public competition.

In the same letter it was said:—"The board have communicated to the contractors the desire of Lord Stanley that the period for which they should be bound to maintain *the cable* in working order be extended from ten to thirty days, and they hope to be able to effect the arrangement."

In the contract with Messrs. R. S. Newall and Co., dated 23rd Oct. 1858, it was stipulated that they "shall manufacture and lay down the cable from Suez to Kurrachee, at their own risk and responsibility, and deliver over the same to the company, complete in full working order, and in condition to transmit ten words per minute."

In clause 5 of this contract, which stipulated for certain payments being made to the contractors as the work proceeded, it was said: "And no part of the money is to be considered as due until the cable, for each section, shall have been efficiently at work, as hereinbefore specified, for one clear calendar month," &c. "Any surplus cable remaining, after the final completion of the contract, is to belong to the parties of the second part (the contractors)."

These documents exhibited prominently the duty of an engineer to exercise great care in drawing up a contract, as well as to see all the provisions scrupulously carried out.

It would be observed that when the tender of Messrs. Glass, Elliot, and Co. was £460,000; that of Messrs. Newall and Co. was £471,425; yet the general result involved in the tender of the former firm was evaded.

It must be borne in mind also, that Messrs. Glass, Elliot, and Co. had stated in their first letter to the Treasury that they had examined the estimates and were prepared to execute the same work at £100,000 less. The directors however overlooked this, and only said they considered the question of £10,000 was immaterial, because they got an undertaking from Messrs. Newall and Co. to complete the cable from Constantinople to Alexandria, and thus to connect India with Europe, which however had not yet been done. It was to be remarked however that no formal undertaking on the part of Messrs. Newall and Co to complete this communication appeared among the official papers.

These details might appear prolix, but it was impossible otherwise to lay clearly before the meeting even the outline of the case, and much more to give a notion of the causes which had led to that lamentable failure.

In the contract, clause 4, it was provided that the board itself, or by its officers, were to have the right of inspecting and testing the cable and all the materials during manufacture and whilst being laid, but so as not to interfere with the process of manufacture. But as regarded the laying, the meeting had been told by one of the engineers of the company that they never had any responsibility, as they never were permitted to interfere in the laying of the cable.

Another condition of the contract was that the estimates allowed 20 per cent. of extra length, in order that the cable might be laid sufficiently slack. Another clause, however, gave to the contractors all such portions of the extra length as were not actually laid; thus actually offering a premium for laying the cable as "taut" as possible. The obvious result was that in consequence of the engineers not having any authority to interfere with the mode of submerging, the cable was laid with so little slack that failures declared themselves almost immediately. Eventually, a vessel was engaged for 182 days in abortive attempts to repair 184 miles of cable.

It was evident that a contract had been made which absolved all parties from responsibility. The engineers had not any power to interfere, and the liability of the contractors was restricted to thirty days. Even here however there was an ambiguity, the government demanded that "the cable"—meaning the entire cable—should be kept in perfect working order during thirty days at least; but the company apparently omitted to insist upon this condition in their dealings with the contractors, as although it was admitted that each of the subdivisions of the cable when laid had conveyed messages during the minimum period, yet no messages had ever travelled throughout the line (beyond one or two days), according to the evident intention and provision of the government, and on the faith of which a guarantee had been granted. It had recently been stated that Messrs. Newall declined to enter into the contract if they were held to the maintenance of the entire line for thirty days. The question appeared to have been settled by a compromise between the company and the contractors, and the public was saddled with the payment of nearly £36,000 per annum; whilst probably all the work would have to be done over again, as the present cable, now lodged on the bottom of the Red Sea, was of no earthly utility, save to the zoophytes, which no doubt were closely attached to it.

Now as to the Rangoon cable. The government requested the opinion of the late Mr. Stephenson upon the form of a cable to be laid between England and Gibraltar, and the suitable construction was pointed out. This recommendation was reported upon by the engineer who was appointed to the project. It was however imagined that the line might be interfered with in case of hostilities; and this cable, which was originally designed for laying in a deep sea, was now ordered to be transferred to Rangoon, in order to its being laid between that place and Singapore, a considerable portion of which route was through comparatively shallow water. The next that was heard of this unhappy cable was, that it was in a state of fermentation, whether from the hemp covering or the oxidation of the iron was not stated; but its destination was again changed, and it was now apparently to be transferred to the station between Malta and Alexandria, to supersede the cable which Messrs. Newall and Co had undertaken to lay for establishing a communication between Constantinople and Alexandria, but which had not yet been completed. The statements of the Blue Books on this subject were curious, and deserved careful attention. As to the construction of the cable, it appeared to be of superior character, and it was a matter of regret that it had not been laid in the place for which it was originally designed.

It was evident that there were in electric telegraphy other considerations beyond scientific knowledge and mechanical skill, and those who had to deal with the subject must be prepared to cope with difficulties arising from other and far different causes. A piece of cable on the table was an instance in point, it was taken from a line laid between England and the Continent for the International Telegraph Company. It contained four conducting wires, and whilst the cable was coiled the whole acted perfectly, but when it was laid only three of the wires were capable of performing their duty. The contractors expended a large sum in ineffectual attempts to raise the cable, and to discover the cause of the failure, during a stormy season. On the return of propitious weather they were more successful, and they then discovered that a nail had been very skilfully inserted into the cable, in such a manner as to destroy the action of one wire. A person who had been on board during the submersion of the cable at length confessed that he had been in the pay of other parties, had at their instigation sought for employment under the contractors, and had, under instruction, inserted the nail. As the case would very shortly be brought before a court of justice, it would be improper to enter into further particulars, but the occurrence justified the severe remarks as to "moral causes" that had been made during the discussion.

Now as to the proper steps for insuring something like a satisfactory submarine telegraphic communication. Although it was essential that a proper route should be selected, it was not requisite to have the entire bottom of the sea mapped out with as great accuracy as had been sometimes contended for, the expense would be too great; and as experience had shown that the destruction from mechanical abrasion only took place within limited depths, the more elaborate survey might be restricted to practical depths, and there it should be minute. For that depth the cable should be strong, and beyond that a smaller section might be used. The extent of corrosion was a serious question, especially where the cable reposed upon sand; and provision should be made for renewal at intervals, say of seven or eight years.

A main point was the form of contract which the government should enter into with parties offering to lay down cables. It appeared that at present few, if any, of the submarine telegraphs were remunerative *per se*,—and with the failures of the Atlantic and the Red Sea cables as precedents, companies would scarcely be found to embark in such undertakings without some government assistance. Then came the question of the terms upon which the government might safely enter into such engagements. After considering all that had been done up to the present time, as described in the Blue Books, it appeared that the safe course would be to negotiate only with such contractors as were known to be responsible and trustworthy, to pay them a sum not exceeding the actual cost of the cable, and then to covenant to pay a liberal percentage for the use of the cable for the period during which it actually remained in working order. The question of the amount paid for effective service was a minor consideration when compared with the fact of saddling the country with an annual payment of nearly £36,000 without the chance of deriving any practical benefit. The subject was one of vital importance, and it was hoped that the expression of opinion during the discussion of the subject would lead to a more business-like consideration of the question elsewhere than it had hitherto received.

March 12.—A statement was read by permission of the council in reference to the remarks which had been made at the last meeting upon the paper on "*Floating Beacons.*" It was stated that seventeen keel buoys had been already constructed, and that there were two on the Arklow Bank and one on the Codling Bank, coast of Wicklow, one on the Butter Pladdy Reef, coast of Down, and one on the north-west Goodwin, in the Gull Stream. The effect which had been attributed to the keel, or prolonged sides, was not only consistent with theory, but had been corroborated in practice, and its action was similar to bilge-pieces, as the function of both was to press against a mass of water which by its inertia steadied the floating body. The principles on which the cone-bottomed buoy and the keel buoy were based, and the mode in which they were carried into practice, were essentially different. For the former it was said, "the mooring ring should be attached near to the centre of gravity and to the plane of flotation;" whereas in the latter, a flat metal plate or keel was added, to steady the buoy by its impact against the water, and by causing the mooring point to be at the centre of lateral pressure, which point could never coincide with the plane of flotation, and in practice was far below the centre of gravity. If properly constructed neither the cone nor the flat bottom would give way; though there was some risk of the rivets which attached the mooring ring on the outside of the cone-bottom becoming loose and leaky, from the continual jerking of the chain; whilst in the keel buoy the mooring casting was like a flat button on the inside of the bottom, the shank only projecting through a central aperture.

The paper read was "*On the North Sea or German Ocean; with Remarks on some of its Estuaries, Rivers, and Harbours.*" By JOHN MURRAY, M. Inst. C.E.

The author first referred to the charts as now published by the best authorities being generally little else than a mass of figures, which even after attentive study could not be long retained in the memory. In this respect they differed from geographical maps, which, being tinted to show the separate states and provinces, conveyed a more lasting image to the mind. If instead of the present system the bottom of the sea were contoured from the original soundings with faint lines, and at every 5 or 10 fathoms dotted; and if the surface between the dotted lines were tinted, and the deep sea engraved in a stippled or darkened manner; the charts would give at a glance a correct notion of the bed of the sea, of a bay on its verge, or of an estuary with a river falling into it. The charts illustrating this paper were contoured and coloured on this principle. Between the land and 10 fathoms inclusive the bed was represented by a tint of yellow; then every succeeding depth of 5 fathoms by orange, red, purple, light and dark blue colours.

The western shores of Ireland, Scotland, and Norway, exposed to the fury of the waves of the Atlantic Ocean, had a great similarity of outline; each being rent into numerous inlets, creeks, and bays.

The great stream of flood from the Atlantic, after traversing the western coast of Scotland, approached the Orkney and Shetland Isles from the north-west, passing eastward through these groups, and after combining with the stream through the Pentland Frith, ran southward along the east coast of Caithness. The same great stream of flood also reached the coast of Norway, and in latitude 62° separated, one branch running to the north and the other to the south. The latter stream impinged upon Kinnaird Head and Rattray Point, throwing a branch into the Moray Frith. The eastern branch of this stream continued its course southward until checked by St. Andrew's Bay and the shoals off the coast of Fife, passing from thence into the Friths of Tay and Forth. In consequence of the Bell Rock and other patches north of it, the stream of flood was divided; and as the flood in the deep water was pressed forward with greater velocity than the streams which traversed the more shallow water of the coast, the main stream arrived sooner, and split off Dunbar and St. Abb's Head, entering the Frith of Forth in a north-westerly direction, and penetrating a considerable distance within it before the other streams which run parallel with the coast. Southward from St. Abb's Head the stream of flood was uninterrupted until it encountered the projecting coast from Redcar eastward, and the tidal waters were in consequence heaped up in Tees Bay. This stream continued its course, and off Whitby joined the main stream coming due south from the deep water. The united streams continued their course to Flamborough Head, sending a branch suddenly round this point to the westward, which swept Bridlington Bay and the low coast of Holderness. Another branch made for the mouth of the Humber; but the main stream took a south-easterly direction, and as the depth of the sea was reduced by an extensive shoal off the coast of Norfolk the stream of flood was forced forward, scooping out in its passage the Inner Silver Pit. From thence it ran into Lynn Deeps, and filled the Great Wash. Another branch scooped out the channels called the Coal and Sole Pits, and continued its course between numerous long narrow banks, which much retarded the velocity of the tidal stream. The stream of flood off Yarmouth resumed its southerly course, hugging the coasts of Suffolk and Essex, until it fell into the estuary of the Thames.

The tidal wave traversed the distance from Kinnaird Head to the East Nook of Fife at the rate of 56 nautical miles per hour, and from St. Abb's Head to Flamborough Head at the rate of 54 miles per hour; but in the deeper water from opposite Kinnaird Head to Flamborough Head the velocity was 60 miles per hour. From Flamborough Head to the Spurn Point, the rate was 38 miles per hour, and from thence to the Well in Lynn Deeps, 49 miles per hour. Over the shoal ground off the coast of Norfolk the speed did not exceed 14 miles per hour; but from Yarmouth Roads to the mouth of the Thames it attained a velocity of about 29 miles per hour.

Returning now to the great flood stream off Flamborough Head, the main set ran almost due east between the shoal ground off the coast of Norfolk and the Outer Well Bank, scouring out a channel, called the Outer Silver Pit, between it and the shoals. Continuing onwards to the Texel, it threw off a branch southward, which made for the mouth of the Thames and the Scheldt; and this current met with the flood issuing through the Straits of Dover, the one neutralising the other. Observations made by the late Capt. Hewett, R.N., in lat. 52° 27′ 30″ N., long. 3° 14′ 30″ E., showed, as had been previously pointed out by the Rev. Dr. Whewell, that no rise and fall of the tide could exist in that part of the North Sea; and that therefore the surface between the two opposite coasts must assume a convex form at low-water by the shores, and a concave one at high-water. The great stream of flood made for the mouths of the Weser and the Elbe, sweeping the coast of Friesland; and being forced in a northerly direction along the coast of Denmark, it impinged on an extensive reef off the extreme point of Jutland which altered its course. It then took the name of an ebb-tide, and after uniting with the constant outset from the Baltic, ran in a north-easterly direction, meeting the flood entering the North Sea between Norway and Scotland, to renew the race it had just run.

The velocity of the tidal wave from Flamborough Head to the Texel was at the rate of 30 miles per hour. From thence to Heligoland it appeared to be propagated at about the same rate; but from thence northwards in the open sea it had not yet been ascertained with accuracy.

The *debris* on the littoral of this sea generally accumulated with off-shore winds, being set in motion by the waves with on-shore gales, and carried along by the stream of flood. A great part of the east coasts of Scotland and England, as far south as the mouth of the Humber, was wasted away by the action of the sea. That of Scotland was carried into its bays and estuaries; but from the Frith of Forth to the Humber, the *debris*, including also the alluvial matter brought by different tributaries into the rivers, and from thence swept by land floods, found a resting-place in the great receptacle of the ocean. As these materials could not pass outwardly through the Straits of Dover, nor northward between Norway and Scotland, the filling process was gradually going on. Hence the gradual shoaling of this sea, the silting up of the mouths of the Rhine and the Scheldt, the formation of the numerous sand-banks on the coast of Holland, and the deposits at the mouth of the Baltic, forming the islands in the Kattegat, and indeed the whole country of Schleswig and Jutland.

The changes which had taken place within historic times on many parts of the east coasts of England and Scotland, were then referred to; as well as the successive inroads of the ocean on the whole line of coast from the Scheldt to the northern part of Jutland, including particularly Holland and Friesland.

The great isolated shoal of the North Sea was the Dogger Bank, situated in the middle of the basin. This was attributable to the immense whirl of the stream of flood, which had been described; and the inference was drawn that, if the tides continued to take their present course, sooner or later this extensive shoal would become an island.

The author next proceeded to consider the effects produced by the action of the tide amidst the Orkney and Shetland Isles, and in the Pentland Frith and on the mouths of some of the estuaries of Scotland; reserving for a future opportunity his remarks on some of the harbours and rivers of the same coast and of England.

Referring to the Moray Frith, it was shown that one part of the stream of flood in this bay had its origin in the Pentland Frith and the several inruns through the Orkney Isles; and these streams meeting off Noss Head, carried forward the flood in a south-westerly direction, and along with it the detritus of the coast into the bay formed by Tarbet Ness, from whence issued the Frith of Dornoch. Its bar was in shape like a half-moon, with a depth of 11 feet at low-water, and a range of tide of 12 to 13 feet at springs. Mr. D. Stevenson, M. Inst. C.E., had ascertained that the level of low-water was the same throughout the Frith to near Bonar Bridge, 17 statute miles from the bar, and that in the river beyond there was a rise of 6 ft. 6 in. in 1700 yards. Also, that the range of a spring tide at Portmahomac, without the bar, was 12 ft. 8 in., and at Meikle Ferry, Bonar Quarry, and Bonar Bridge, within the estuary, it was respectively 13 ft. 5 in., 13 ft. 8 in., and 6 ft. 10 in.—the velocity of the tidal wave between these places being at the rate of 22 miles, 7·4 miles, and 0·66 mile per hour. The diminished rates were caused by the contraction of the estuary, by the less depth of its channel, and by the reduced sectional profiles from the mouth upwards. It was then estimated that the water-shed area of the rivers amounted at ordinary times to 3246 cubic yards per minute, or about $\frac{1}{123}$th part of the total discharge from the frith; but in the drought of summer the whole of the fresh-water streams were insignificant in comparison with the capacity of the estuary below Bonar Bridge, and the Kyle of Sutherland above it. The maximum surface velocity of the ebb tide at Meikle Ferry was found to be 2·55 miles per hour, and the cubic contents of the estuary within Dornoch Point amounted to about 155,128,100 cubic yards. Assuming the duration of the ebb as 6 hours 22 minutes, the total quantity of water passing out of the frith would average 406,094 cubic yards per minute, giving the maximum velocity through the section at its mouth of 2·66 miles per hour. In the open sea therefore, over the bar situated upwards of 4 miles from Dornoch Point, the maximum velocity of the ebb could not exceed the rate of 1 mile per hour. Notwithstanding the gentle velocity of the stream of ebb out of this estuary, with the duration of flood and ebb nearly alike—conditions under which it had been contended that no bar could be produced—there was one at the mouth of this frith as well defined as in any tidal river. Other authorities were of opinion that bars were composed of matter held in suspension, and deposited when the current met the still water of the ocean. But in this case there was not a sufficient quantity of detritus carried down the rivers falling into the estuary to produce a bar of sand like that in question, which could only be caused from the indraught of the sea carrying the finer sands up the estuary. Violent on-shore gales drew off from the shores as well as raised from the bottom the sand and gravel accumulated during calm weather and westerly winds. The sweep of the flood tide carried along the detritus, and conveyed some of it into the seaward part of the estuary, where it was deposited. Other portions formed a beach across its mouth, which would effectually bar it if there were no tidal currents to maintain a channel. What was carried into the estuary on the flood with on-shore gales was, on their cessation, swept away by the outset of the ebb, and returned to the ocean. The bar of this frith was exposed to the full force of a gale from the north-east, and at such periods was found to be in its worst condition. Under-currents on the flood tide, when subjected to the stroke of the sea, tended to increase its height, and the author attributed its formation to this cause more than to any other; for the bar was in its best state in calm weather after a continuance of land floods, especially if these were accompanied by strong spring ebbs.

A second part of the flood tide entered the Moray Frith from the deep water, and the consequence of the meeting of this stream with the one formerly mentioned was an extensive deposit of sand between them. The stream then passed onwards to the Frith of Cromarty.

A third part of the flood, and evidently the most powerful, also entered the Moray Frith from the deep water, running parallel with the coast from Kinnaird Head westward, filling with tidal water the Frith of

Inverness, and carrying along with it the detritus of about 80 statute miles of coast. The consequence of this sweep of tide was various deposits, which had reduced the entrance to the Frith of Inverness to 1400 yards, with a depth of 23 fathoms at low-water spring tides. Through this comparatively narrow but deep channel both the streams of flood and ebb ran with considerable velocity. In former times the mouth must have been as much exposed to the action of the waves as the Dornoch Frith, with a similar bar outside; but none now existed.

The entrance to the Frith of Cromarty was through a gorge between the headlands called the Suters. This gorge had an average width at high-water of 1600 yards, with a maximum depth of 28 fathoms, and its length was upwards of 1¼ mile. After passing the strait the frith opened out into a wide expanse, which, afterwards contracting, had an area at high-water spring tides of 32¼ square miles, and at low-water of nearly 16 square miles. The rapidity of the regular currents through the strait caused a vessel to steer well and steadily when seeking shelter; and the expansion of the estuary allowed the swell of the waves to be dispersed, a matter of great importance in a haven for shipping adjacent to deep water outside. Mr. Alan Stevenson, M.I.C.E., had ascertained by observations carefully made, that during flood the surface velocity through the entrance was 1·8 mile per hour, while at the depth of 50 feet the velocity was not less than 4 miles per hour. During the ebb the surface velocity was 2·7 miles per hour, and at 50 feet below the surface the velocity was not less than 4½ miles per hour. These under-currents flowing into and out of the Frith of Cromarty were so interesting, as to lead to further investigation.

In this frith the action of the flood tide was by far the preponderating force. The bar, deep as it might be under low water, was no less a formidable bank beyond the line of the coast, and the flood tide, after passing it, pitched into a pool, then ran through the minimum section in the gorge, pitched and rose again, and continued this undulatory motion for several miles up the estuary. This recalled the theory of M. Emy, named by him the "flots de fond," or action of the waves on the bottom. A very similar action existed in the Dornoch Frith. It was the same in the Tay, the Tyne, the Humber, the Thames, the Mersey, and other rivers. It was met with at still greater depths in the open sea, as in the English Channel, at the northern entrance of the Irish Sea, in the Straits of Dover, and particularly well defined at the entrance of Moray Frith, and at other places noticed in this paper. The author thought it must be evident that the flood only could produce these depths, and that the waters of the ebb could have no such effect. It was in his opinion caused by the tide, accompanied by waves and under-currents from the deep water of the open sea, acting on the bottom, diminished in force and perhaps imperceptible at the surface. In all rivers it might be noticed that, when in flood after excessive rains, the fresh-water appeared on the surface to overpower the force of the flood tide, and in many cases throughout nearly its duration; but at such times, if properly examined, it would be found that an under-current of salt-water was running inwards from the sea near the bottom, arising from its greater specific gravity, and the tidal action exerted upon it from the ocean. If the fresh-water were not so powerful, but yet muddy in character, the current from the sea was often clearly defined, making its way inwards like a long tapering wedge, but which beneath was spread along the bottom from side to side of the channel, until it quite overpowered the descending stream. when the whole of the section became salt-water.

In conclusion, it was remarked that these three contiguous friths afforded information which might prove useful in designing marine works:—

1. That in the Frith of Dornoch the bar was exposed to the full force of the sea, and no works of an ordinary character could get rid of it in its present situation.

2. That the bar had been removed from the Frith of Inverness by natural means, well worthy of mature study.

3. That the Frith of Cromarty had, from the peculiar and happily-placed position of its entrance, a bar, it was true, but submerged at a depth practically of no inconvenience.

EXHIBITION OF THE SOCIETY OF BRITISH ARTISTS, SUFFOLK STREET, PALL MALL.

In this, the thirty-eighth annual exhibition, will be found the average proportion of successful and unsuccessful productions, the numbers perhaps inclining to the former, especially in the unusually grand figure-compositions of the president, who appears this year to have excelled himself, and the three all-but-perfect landscapes by Mr. Vicat Cole. To these may be added a large subject by Mr. G. Cole, called "Pride and Humility" (595), in the style of Sir Edwin Landseer's famous works, and painted with a masterly hand. These constitute the gems of the collection, and will of themselves repay a visit to the gallery; while of the lighter class we recognise with pleasure the genial and poetic visions of Mr. Woolmer (seven in number), a beautiful little picture by the veteran J. B. Pyne (73), some exquisite Welsh and other scenery, portrayed with the practised skill of Mr. H. J. Boddington, and several equally charming sea-pieces by Mr. Syer. We also noticed, *en passant*, Mr. F. W. Hulme's "Village green" (47), Mr. T. Banks' "Heath in flower" (539), in which the pebbles in the bed of a stream are shown with pre-Raphaelite minuteness;—Mr. Leitch's "Reminiscence of the Rhone" (646), Mr. Wolfe's two Cornish scenes (659) and (673), Mr. F. A. Roberts' "Christmas carol" (734), Mr. Delamotte's "Lych-gate" (761)—at Beckenham, to all appearances,—and Mr. Pidding's "Conflicting accounts of the engagement" (244), a Greenwich Hospital scene, of the Wilkie school, and capitally rendered.

As may be expected, there is scarcely one exclusively architectural subject, those by the Messrs. Rayner being the most so, and maintaining their well-earned reputation. One of the first we have noted in our catalogue is by Mr. E. Boddington, "Albury old church" (20), a very truthful painting of a very picturesque spot;—then come Mr. G. B. Moore's "Monument of Can Lignoria, Verona" (132);—Mr. Lucker's grandly solemn "Hypostyle Hall, Luxor" (216);—Mr. Bates' "Rochester,—evening" (392), a good representation of the old bridge, and castle behind it;—a small and careful sketch by L. J. Wood, of the "Rue de la Porte, Dinan, Brittany" (453);—"The Cavalli Palace, and Church of Santa della Salute, Venice" (472), by Mr. W. Henry; and another of the "Entrance to the Ducal Palace, Venice" (553), by the same artist. Mr. J. P. Pettitt's "Neath Abbey, South Wales" (577), is one of the most charming little views of the kind, though somewhat crude in the colouring; and Mr. Bayliss has one or two clever gleanings from abroad, such as (660) "Malines Cathedral," (682) "The old church of St. Martin, Ghent," and (839) "Rubens' Chapel at Antwerp." From the latter town we have also another picturesque sketch, by Mr. H. Jenkin, (792), which shows the curious old houses in the market-place, and a distant peep at the cathedral. The "Tower of Comares, in the Alhambra, Spain" (797), by Mr. J. Dobbin, is a contribution *per se*, consisting of a series of strangely combined forms, especially in their fancifully broken sky-outline. Some few others, which are deserving of notice more on account of isolated scraps of detail than the delineations of their general mass, will be readily detected, but need not be here particularised; our object being to refer to those only which, on the whole, merit attention.

FOREIGN PUBLICATIONS.

In our last article under this heading the intention was expressed of returning to the *Monographie de la Cathédrale de Chartres;* and it is in truth so magnificent a publication, that it is a pleasure to have to refer to it again.

The later plates issued illustrate the stained glass, and some fragments of the mural decorations, in colour. The finest of the stained glass illustrations is one showing a single-light window, of the twelfth century, from the western front, and executed in colours to one-sixth of full size. The subject is one of frequent occurrence—the Tree of Jesse, and is treated in much the same manner as usual; but the beauty of the colours, the severe nobleness of the drawing, and the richness of the ornamental border and of the ornaments attached to the tree itself, all combine to render this a fine study. It is also beautifully rendered, the colours being given with a depth and a brilliancy rare in chromatic illustrations.

Of thirteenth century glass we have, in bold outline only, and also to one-sixth of full size, a similar window, known as "Notre Dame de la belle verrière," and having for the principal subject the madonna, surrounded by angels with censers; and below, nine subjects from the history of our Lord, illustrating the Marriage in Cana, and the Temptation. This is a magnificent window, the groups in the smaller subjects being especially fine. Of the same date, and illustrated in the same style, and to about the same scale, we have two noble windows out of a series of four containing the four evangelists and the four greater prophets; and to a smaller scale a window containing a single figure of St. George.

To a smaller scale (about one-fourteenth of full size) we have three noble windows, conspicuous alike for the grace and beauty and inexhaustible variety of the diapers and ornaments, and for the power shown in the treatment of the subjects. These windows represent respectively the parable of the Prodigal Son and the history of Charlemagne and of St. James. A sheet of details to a large scale are also given from St. James's history. The two windows having scripture subjects are the most nobly executed, and indeed the one of the Prodigal Son can hardly be surpassed for the beauty of the various groups it contains; but as an authority on points of civil and military costume the Charlemagne window will be perhaps the most valued.

Lastly we have some plates of grisaille, of the fourteenth century, given in colours, and most exquisitely rendering the peculiar tone of the glass.

The execution of all these plates, it is right to add, is free from many of the defects that beset French work even of a high class, and nothing can surpass the genuine artistic feeling shown both in the representations of stained glass, and in the details and fragments of sculpture, some of which are executed in lithography, but the majority on copper. This is of course a costly work, but a more appropriate volume for public institutions, and for private architectural collections of the first class, can hardly be pointed out.

Nouvelles Annales de la Construction.—This periodical is one which would be found interesting by many of the readers of the *Civil Engineer and Architect's Journal.* Last month we printed two short extracts from its columns; we now proceed to give a slight account of the journal itself, as far as the parts for the first quarter of the present year will enable us to do so.

Nouvelles Annales appears to be distinguished from many of its contemporaries by a quality which would make it acceptable to English readers—namely, considerable literary merit. The characteristic of many French publications is the marked superiority of the illustrations over the text, but we have not to complain of such a disparity in this instance. The journal is intended to include designs and suggestions, leading articles, and descriptions of the buildings and works illustrated by engravings; intelligence on building and railway matters, and on telegraphy, navigation, and new materials; reviews of books, and of British and foreign periodicals; proceedings of learned societies; prices and statistics; formulæ, correspondence, problems. The illustrations, though not equal to much of the best French work, are quite as good as are needed, and in fact better than could be expected in a periodical published at a very moderate price. The majority of the subjects are such as will interest the engineer more intimately than the architect; but matter suitable to both classes of readers, and very varied intelligence, is to be found in its columns.

We note in the January number plans and a short description of an ordinary French dwelling-house lately built in Paris; and as the erection of a class of dwellings arranged in flats like those of the French is really needed in this country, and is much talked about, a few particulars are not likely to be out of place here. This house is built with fire-proof floors on iron joists, and occupies, exclusive of courtyard at the back, a site having a frontage of 14·9 metres by a depth of 9·53. There is a story of cellars, and seven habitable stories, of which the ground-floor forms as usual a shop, with a passage leading to the entrance to the *appartements*, or suites of rooms. The attic story is arranged for letting in single rooms, and the five intervening floors are arranged as tenements for letting, there being two tenements or *apartements* on each floor, and a common staircase from bottom to top. Each of these sets of rooms—which it is quite needless to say are most compactly planned, that being a quality in which the French never fail—contains a sitting-room, measuring 14 ft. 9 in. by 12 ft. 6 in.; a bed-room, 14 ft. 9 in. by 10 feet; a dining-room, about 10 feet by 9 feet; a small kitchen of irregular shape, measuring about 50 superficial feet, a roomy cupboard, and a convenience. The details of cost, &c. are given, from which it appears that the entire cost was at the rate of £224 sterling per square of 100 English feet, which, divided by 8 for the number of stories, gives an average price of £30. 16*s.* per square per floor, and the cost per cubic foot appears to have been 7½*d.* English. Both these amounts would be fair average approximate prices for the same class of work in London, or, if anything, would be above London prices. The average letting price is stated to be 10 fr. per superficial metre for each story, or 1413 francs per floor, which, multiplied by 6 for the habitable floors and shop (excluding the attics and cellars) gives the gross rental of 8478 francs per annum upon a total outlay of 94,212 francs, or very nearly 9 per cent. From this rate of profits, of course, heavy deductions must be made for ground-rent, collection of rents, loss by tenants, &c.; but as something has, on the other hand, to be added for rent of cellars and attics, it will be clearly seen that, if these figures are to be relied on, building in Paris, if expensive, is profitable. It is worth noting, that the average of 1413 francs per floor gives an average rental of 706 francs, or £28, per tenement; and as the rents of the upper floors will be much below the average, and those of the lower ones much above it, there seems reason to presume that even the modest suite of rooms we have described would, on the first floor, cost from £40 to £50 per annum for rent alone, exclusive of all other expenses whatever.

We give an extract from the *Annales* in another portion of our columns, on a subject of great general and engineering interest—the present position of railways in France.

The Study-Book of Mediæval Architecture and Art (volume ii.), by Thomas H. King, architect, Bruges, with descriptions by George J. Hill, M.A., is a work which we feel no hesitation in including in our notices of foreign books. Although published in London (by Bell and Daldy), and containing letterpress in English and by an English writer, this is in reality a foreign work. Not only are the subjects all continental, but the illustrations by the Bruges architect far overpower in number and importance the English accompanying letterpress; they, moreover, are in part lettered in French, and have been printed at Paris. This book, of which only two volumes out of four are at present published, is one of the most encyclopædiac works ever attempted on continental Gothic church architecture. A review of volume i. will be found at page 131 of this Journal for 1858. Into these two volumes—quartos of not unmanageable size—there are compressed illustrations of fifty churches, most of them cathedral churches of the largest size. There is nothing like an attempt at book-making in the work; on the contrary, the plates are filled with information to the utmost extent; each church is as fully illustrated as possible, and with a praiseworthy desire to keep down the number of plates, and to compress as much information as possible into the volume, no more is given of any part of any building than is necessary. For instance, cross-sections are often divided, half looking east, half west; one or two bays of longitudinal sections or side elevations only are given, instead of complete drawings; and details such as plans of piers, mouldings, and enrichments, are furnished wherever a space on the sheet could be found. The excellent plan is also followed of employing an uniform scale for the same drawings of each church, so that the main dimensions or relative magnitude of two churches can be ascertained at a glance. The ground plans are all to a scale of 1 to 500; elevations and sections to a scale of 1 to 300, and so on.

The author, in his preface, referring to the accuracy and care with which the plates are executed, observes—"In this respect they challenge comparison with any which have yet been published. I have not in a single instance trusted to the measurements of previous archæologists. The details have been all drawn, the plans, sections, and elevations measured, expressly for the work, and under my own eye. I am able, therefore, to vouch for their authenticity." We do not of course pretend to have checked all these measurements, but from the painstaking way in which the book is got up, and the accuracy of the general drawings of some examples with which we are familiar, we should be disposed to rely upon the illustrations given here in preference to many others. In one respect, however, they are not very accurate—architectural *character*, especially in sculpture, is not uniformly well preserved, nor are mouldings always perfectly contoured; but in both instances they are near enough to the truth to give a fairly good idea of what is meant. A moderate price rather than a splendid series of plates has been aimed at; and to preserve this, and at the same time to give the profusion of illustration afforded, it was necessary that some amount of finish should be sacrificed. As a specimen of the fulness with which interesting subjects are treated, we may instance the church at Auxerre, to which fifteen plates are devoted. These plates are only large quarto size, and yet there are upwards of one hundred illustrations of the building compressed into them. Other churches are illustrated in like manner, the subjects being taken from both France and Germany. The inaccuracies of detail above referred to form the only blemish in this very remarkable and interesting work, but they will not prevent its being extremely valuable. The descriptions appended to the plates are brief, and more antiquarian than architectural in their import; as far as they go they are, however, very good.

THE EXHIBITION OF 1862, AND THE METAL MANUFACTURES OF GREAT BRITAIN.

A LECTURE on the above subject was recently delivered before the Ironmongers' Association, by the Rev. C. Boutell, M.A. Referring to the forthcoming Exhibition, the lecturer said that the preparations had begun in good earnest; the guarantee fund was now more than sufficient. As to the proposed building itself, it did not appear to him to be creditable to the country. What could the engineer-architect mean by having two domes, one at each end of the building? though probably one in the centre might have been of some service;—in an architectural or engineering point of view the building was by no means satisfactory. At the same time there was an amount of preparation in active exercise which would unquestionably secure the erection of a building that would be suitable to contain what was to be exhibited, and they might be sure it would be ready at the time required. Then they wanted to see what was doing in the way of preparing for its contents. The former exhibition contained an enormous proportion of singularities and eccentricities—odd things, many essential, many remarkable, and many worthy of the attention paid to them. All things found a place in the marvellous Exhibition, but many of them were of such a character as should not be sent again. It must now be shown that the first Exhibition had had a practical effect on their minds.

He came now to the subject which he had specially before him,—the representation of the manufactures of metals. They must make all they made as examples which might be copied ten thousand times if required. All the things prepared for the Exhibition, if they wished them to be creditable to themselves, must not be exceptional, but should be typical specimens of what was done every day. They must not be eccentricities or curiosities, but specimens of what could every day be done in metalwork—never mind how simple the object, or how slight the apparent use. If that idea was carried out the Exhibition would not only be a grand display, but a monument of the high position of the workmanship of England. With reference to the metal manufactures, they stood in a most prominent position among the manufactures of England. In fact, the hard metals were endless in their varieties and use, and possessed almost a national character. The iron and copper of England worked up in the form of brass had been for ages especially regarded as English work. England certainly stood well in the front of the producers of the manufactures of iron; but in the coming Exhibition it was not one great producer that would have to encounter another great producer, but all would have to encounter a keen rivalry from the workmen in iron in foreign countries. But he was sure they would not allow the manufactures of iron of foreign countries to beat the manufactures of iron in this country.

In the Exhibition of 1851 the art character of the object exhibited was infinitely inferior to the manipulative skill employed in their production. All the best metalwork produced in our time was made with the apparent intention of showing that it did not belong to this age, but to make it appear to have been the production of mediæval times. But they should not desire to produce good metalwork now because good metalwork was produced in the middle ages, but they should show that good metalwork could be produced at the present day. They should study the art feeling of the mediæval times, both in design and execution, and take hints from them; but they should make their metalworks unquestionably modern works, though Gothic; and let them not call it Mediæval. We wanted our works to express the sentiments of our own times, and to be suited to our own wants. They ought not to copy, but to exercise fresh, independent thought. They must not take up an old design, and copy it without thought of their own; they ought themselves to produce, and not to imitate or copy something which a Gothic or Greek master did—though by the way, it was not found that much in metalwork had come down from the Greeks. They should take the best things in all styles by way of example, and then use their own thought and form of expression. They should exercise their own thought, their own brain, their own mind. He was most anxious that the metal manufactures at the Exhibition next year should stand pre-eminent, and show to the world that English metalworks were the best.

The lecturer then spoke in favour of wrought work as being superior to castings; the more they got rid of castings the more successful would be the results of punching or cutting either by hand or machinery. They must aim at producing everything that was produceable; and the commonest thing of whatsoever kind should, along with the more important, bear the impress of the same mind and the touch of the same hand. He hoped that that would be one of the characteristics of the coming Exhibition. If the Great Exhibition of 1862 was to be successful its contents must be specimens of what skilled workmen could do, and also illustrate what was popular amongst the people. Wherever there was any important architectural work they were sure to find some cleverly-designed and well-executed metalwork; and in the simplest portions of it, such as the stanchion of a window, as well as in the highest, there should be evidence of the same thought and artistic touch.

After remarking that the balusters of staircases might be very well executed in metalwork, the lecturer said, architectural accessories in metalwork should be well represented at the coming Exhibition; and then referred to the novel appliances of iron in naval and military architecture, which in his opinion ought to have their close attention. He also suggested that iron might with advantage be more used in the construction of both private and railway carriages.

NEW CHURCH, INCE-IN-MACKERFIELD, LANCASHIRE.

(*With an Engraving.*)

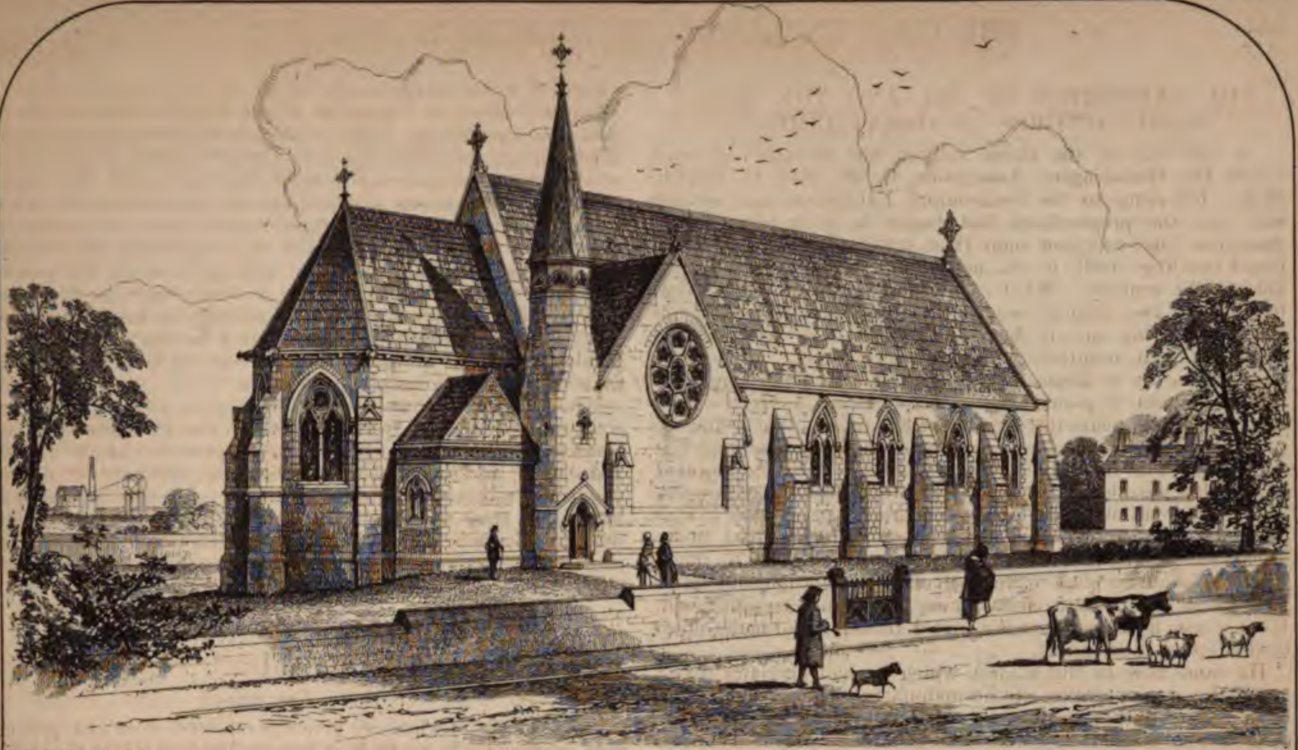
THIS church, of which we give a perspective view and ground plan, is intended to be built at Ince-in-Mackerfield, in the midst of the great Lancashire coal-field, and two miles from Wigan. The district proposed to be assigned to it out of the parish of Wigan, contains about 7000 inhabitants. The site, which has been given by Capt. Anderton, adjoins the Lancashire and Yorkshire Railway. The church will be built of Parbould stone, with dressings of Up-Holland walling stone. The total cost will be about £5000. The architect is Mr. E. G. Paley, of Lancaster; and the work has been taken by Mr. Fairclough, of Wigan.

OUTWELL CHURCH, NORFOLK.

(*With an Engraving.*)

WE give also in Plate XVI. a view of one of the fine old Perpendicular churches for which the county of Norfolk is famous. Outwell is situated about six miles south of Wisbeach, and is therefore on the borders of Cambridgeshire. The church consists of a nave with north and south aisles, chancel with north and south chapels, an additional chapel on the north side placed transept-wise, and called the "Lynn Chapel," a western tower, and south parvise porch. With the exception of the lower part of the tower the whole church appears of the same date. From the proportions of the tower it may be easily inferred that the earlier church to which it belonged was of much smaller dimensions than the one now existing. With respect to the present state of the building, the old story holds good—long neglect and consequent dilapidation. The chancel, too, is slipping into the river at the east end: some years ago an attempt was made to arrest this by means of iron ties, but they have been found ineffectual: a new roof was put upon the chancel,—this roof is a common queen-post roof, with a lead flat over the straining pieces, and ceiled under the tie-beams, and therefore cutting the tracery of the east window in half. All the other roofs are the original ones, and are richly carved: that over the Lynn Chapel is one of the richest and most elaborate we remember to have seen, and it still retains traces of the coloured decoration. The effective base-course round the exterior of the south aisle is nearly hidden by the accumulation of soil; and there is a miserable brick external staircase to the room over the porch, the original circular staircase inside the aisle being in such a worn and dilapidated condition as to be useless.

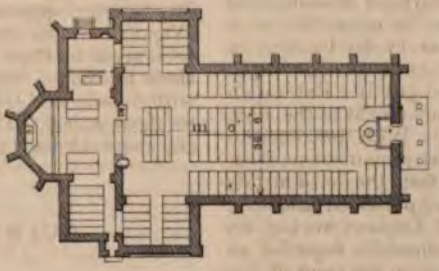
The works proposed are the rebuilding of the chancel, reducing its length to 34 feet, so as to avoid any danger of the foundation giving way at a future period, the thorough repairing of the roofs, &c., the reseating of the whole of the church, and generally restoring the fabric as requisite. The estimated cost of the work is nearly £3000. The architect engaged is Mr. William Smith, of New Adelphi-chambers, London.



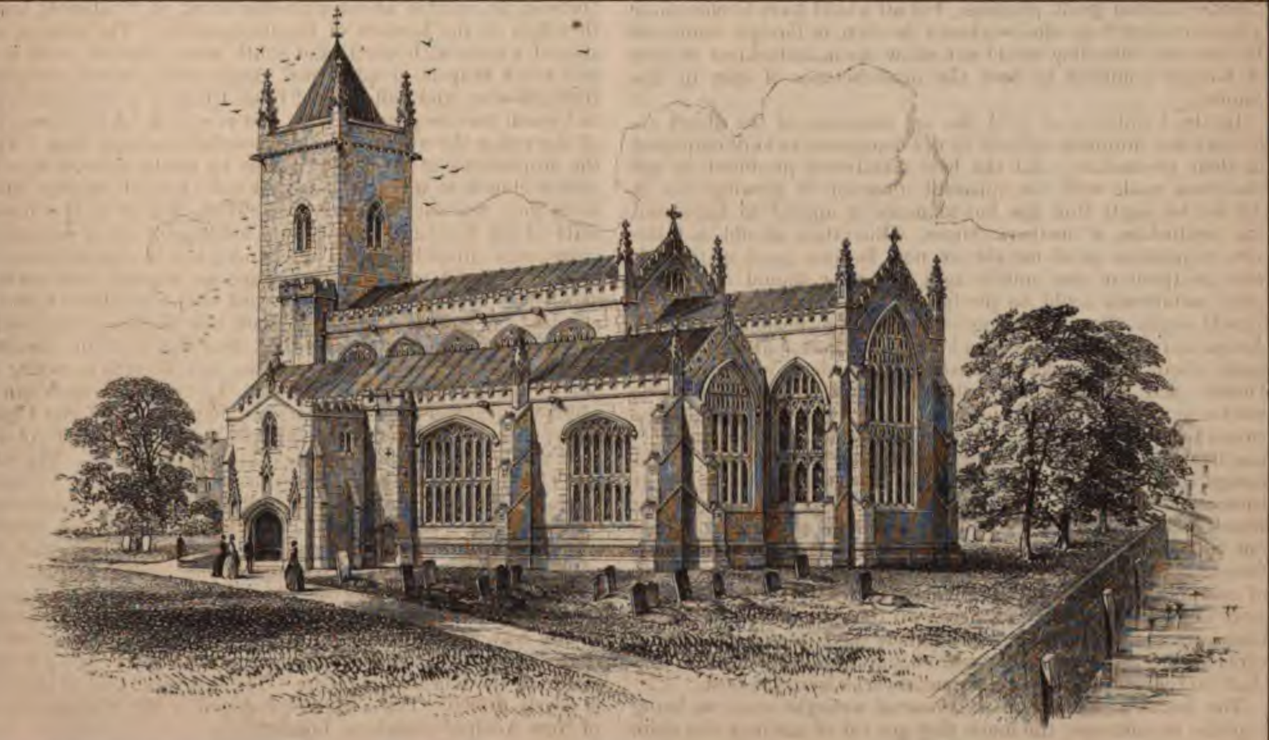
E.G.Paley, Archt.

J.R.Jobbins.

N.E. VIEW. NEW CHURCH, INCE IN MACKERFIELD.



Ground Plan



S.E. VIEW OF OUTWELL CHURCH, NORFOLK.

(Restored)

Wm Smith, Archt.

BUILDING MATERIALS, INVENTIONS AND PATENTS AT THE ARCHITECTURAL EXHIBITION.

THE department of practical art, is a summary expression which may be used in describing this portion of the Architectural Exhibition, which is slowly, but we hope surely, progressing in public estimation, if we may judge from the many exhibitors of last year who have renewed their engagements for "space," and the fact that the whole of the area contemplated in originally planning the rooms, to be allotted to these objects, is now for the first time completely filled. The importance of the purposes sought to be accomplished by these means cannot be over-estimated, whether we regard the art-workmen, architects, or their clients: it therefore behoves the committee to extend, if possible, the limits already occupied, so that there may be no cause for rejecting future applicants for show-room, and thereby checking the full utility of this most important branch in connection with the interests of the profession generally. It has been suggested that more use might be made of the central areas in the picture-galleries, but to this we demur—over-crowding would inevitably ensue; for, as it is, the aspect of the room is sufficiently cheerful and inviting, and the introduction of more tables and stands would interfere sadly with the appearance (at any rate) of comfort, and might in other ways prove undesirable. Should the opportunity offer of enlarging the galleries, which is said to be by no means improbable, we trust that the committee will feel themselves in a position to avail themselves of it on advantageous terms; but to enable them to do this will require, not merely the good will, but the helping hands of all who desire the increasing prosperity of the institution.

It will be unavoidable, in pointing out the leading "practical" objects in these galleries, if we now and then repeat what we have in substance recorded on previous occasions; but there is no need for claiming indulgence on this score, since such matters have claims which cannot be too frequently pressed upon the attention even of those persons to whom they are thoroughly familiar, while not a few strangers will doubtless be induced by the bare mention to attend and examine for themselves. Upon the merits of world-famed articles like those manufactured by such as Minton and Maw in tiles and pottery, by Hardman, Skidmore, or Hart, in ornamental metalwork, by others in stoves and the more ordinary kind of metalwork, with a variety of handicrafts which are more or less practical accessories to our profession, it is needless to dilate. Some of these establishments have been represented in the exhibition galleries from the first, while the mere fact of trade-emulation has produced, in each successive year, manifest improvements which it is by no means likely would have been elicited in the same period of time by any other means.

With the assistance then of the catalogue, we find, in the lobby of the North Gallery, (1) "Specimens of Martin's cement," an article which has long approved itself as among the best of its class. It may be applied to various purposes, as the several specimens on the walls will show. The "Scagliola marble" (2) of Messrs. Bellman and Ivey we noticed with commendation last year, and the specimens before us appear to be the same. Messrs. Peard and Jackson's "Mediæval metalwork" (3) displays commendable zeal and skill in the working, according to ancient principles. They exhibit, among a host of articles, a wrought-iron grille, well designed and very carefully finished. The same firm also exhibit (3) "Specimens of Brown's patent cloth-padded wood strips," for rendering window-sashes, casements, doors, museum and show-cases, air, dust, and water tight; also models exhibiting the manner of applying them. No. 4 is devoted to specimens of Ransome's patent siliceous stone, to which we have before adverted. The Poole Architectural Pottery Company send, as heretofore, a variety of samples of their productions, which are well and approvingly known. Some large flower-stands for conservatories, orange trees, &c., constructed of tiles on a metal framework, are suggestive of purposes to which these manufactures can be applied.

Zinc, as a material for roofs, is now much in demand, and the most secure and efficacious mode of laying and jointing it is necessarily an important thing to determine. Mr. J. W. Tyler in his models (6) appears to have met the difficulties satisfactorily, by a method which is not effected by atmospheric influences, the metal being laid without nails or solder, thus allowing of its contraction or expansion according to circumstances. The models of zinc work exhibited by Mr. Tyler are actual working models, made for works which have been executed upon the new system introduced by Mr. Edmeston, architect, and which was noticed at page 85 of this Journal for last year. The zinc is supplied through Messrs. Charles Devaux and Co., of London, the eminent bankers and merchants, under special arrangements, so that they can give their guarantee of purity by stamping each sheet with their name. By Mr. Edmeston's advice they also stamp none but sheets of proper thickness for roofing, and therefore sheets too thin for the purpose can never be supplied to those who use their zinc. The workmen employed by Mr. Tyler, of Wood-street, Westminster, have become expert in the new method, and a great number of roofs have been laid by them in London and the country, with great satisfaction to employers and their architects. By this covering, the constant expenses attending slate and tile roofs are got rid of; and this relief from expense and annoyance, it is said, has caused this mode of covering to be so universally adopted on the continent. Mr. Tyler also shows a small model of his "Patent octagon chimney-head," for the cure of smoky chimneys, especially adapted for bleak and exposed situations.

"Wright's patent self-acting water-closet" (7) will still recommend itself, as a simple, economical, and effective apparatus, so constructed (we are told) as to be "free from all defects of the water-closets in general use." Another arrangement of water-closets may be seen in (9), exhibited by Messrs. J. Tylor and Sons. These do not require any separate cistern apparatus, cranks, or valves; and by a simple contrivance the amount of supply of water can be adjusted at pleasure. Great attention also appears to be given to the construction of the metal valves.

Mr. W. Hood's "Stable fittings" (8) show much ingenuity and economy of space. "The advantages claimed for them are—1st, that waste from the rack is prevented by a spring rack top, which opens back to the wall while the rack is being filled, and descends as the hay is being withdrawn, always so compressing it that the horse is unable to remove it wastefully; 2nd, a perforated cover is applied to water cistern, working in slots, so contrived that only persons acquainted with the use of it can open and close it; 3rd, the tubes containing the noiseless tying apparatus act as brackets for supporting the stable fittings, and also keep the halter-balls away from the horse's feet. The price varies from 35s. to 125s." The lamp-post, panels, and other ornamental castings exhibited by Mr. Hood, are not in the best of taste, and rather coarse in execution. Several earthenware materials, such as drain pipes, electric pipes for cables, ridge tiles, &c., are furnished (10) by the Reading Abbey Concrete Works, London-street, Reading, an establishment of which as yet but little is known. Brown and Green's kitchen range has many recommendations. It is warranted a certain cure for a smoky chimney, and will burn either coals or coke, consuming only one-half the fuel of an ordinary range. The upper part of the front of the fire is inclosed, when cooking, with a perforated iron plate, through which jets of air are directed upon the smoke, by which means the greater portion of it is consumed, and the heat of the hot plate, &c. thereby greatly increased. This plate is in several respects a great improvement upon the usual doors; it is not liable to get out of order, and not projecting beyond the line of the fire-bars it economises heat by preventing a draught of cold air over the fire; also, being brought into immediate contact with the fuel it becomes slightly red-hot, and thus renders the whole depth of the fire available for roasting. The sliding-plate over the fire is also much more convenient than covers that lift off. When not cooking, the front of the fire may be perfectly open. This range is fitted with two ventilating pipes, which carry off the odours of cooking. The oven is large, well ventilated, and thoroughly effective for roasting, or baking bread or pastry, being constructed on a plan by which it is heated on all sides alike. This is attained by means of the hot air passing from the fire through the iron flue surrounding the oven. Brown and Green's improved self-acting midland cottage range also supplies a desideratum. The ovens and boilers are self-acting, and are quickly and effectually heated with a remarkably small quantity of fuel. It is moderate in price. (12) Chantrell and Dutch's patent economic self-acting water-closet and water-waste preventor has been described by us before. This apparatus combines a cheap glazed stoneware cistern, with measuring box, double action valve, with vulcanised India-rubber washers, overflow, and air-pipe; white enamelled stoneware hopper basin, and syphon trap ball-cock, for supply; simple self-acting lever and rod; 7 feet of flushing pipe, with connections to cistern; pivot hinges for seat. Price complete, exclusive of timber work, delivered to rail at Liverpool, £2 15*s*. The apparatus may be fixed by any ordinary workman, and the valve may be taken out for repairs by disconnecting the flushing pipe, and removing the plates on the underside of the cistern; there being no screws (to be affected by water) in the valve, it is almost indestructible. The cistern contains sufficient water for thoroughly flushing the closet seventeen times, which is a great advantage over many other apparatuses which have only one charge, so that whenever the water may be off at the main the closet gets out of order for want of water for flushing it. The apparatus is adaptable to slate and other cisterns, and for all flushing purposes.

Messrs. Mander's varnish maintains its pre-eminent position as a clear, hard-drying material, admirably adapted for seats of churches; their white Coburg varnish is the palest in the trade. A panel coated with the latter is exhibited, for the second year, without being re-varnished, and it does not display any change of colour. Moore's clock and illuminated clock-dials, and also his patent ventilators (14), are now so well known as not to require description. Messrs. Sharpe Brothers and Co. have patented an improvement in closet pans (15), by which the water is distributed in an efficient and equable manner throughout. The rim to these pans is formed into a tube, which conveys the water entirely round the upper edge, and being there acted upon by the pressure in the supply pipe, it descends vertically (through proper openings) over every part of the surface. The openings are made of different shapes and sizes, in order to govern the action and determine the quantity of water which shall pass over the several parts, and thus secures a heavier flow where it is found by experience that most is needed. These pans do not require fans or spreaders of any kind, and the cost scarcely exceeds that of ordinary descriptions.

Godwin's encaustic tiles and self-coloured tesseræ (16) are manufactured on an extensive scale at Lugwardine, near Hereford; and they are now brought to that degree of perfection as fairly to vie with any others in the market. The purity of colour and perfection of shape which they now possess can only have been the result of repeated and persevering experiments. Gill calorifers are in frequent use for warming churches, public buildings, mansions, &c. Those produced by Mr. G. Wright, of Sheffield, are among the best. One of the smaller sizes is shown in this exhibition (17), and is calculated to warm a building having an area of 50,000 cubic inches. The feed and ash-pit doors, or valves, are so constructed as to give perfect control over the amount of air admitted to support combustion. No. 18 presents an extensive show of locks and lock furniture, exhibited by Messrs. Bond and Scammell, of King-street, Snow-hill; and No. 19 is a similar case, exhibited by Messrs. Hobbs, Ashley, and Co., of Cheapside. Among these latter may be noticed an excellent mortice lock, in which, by the application of the double spring, the latch is made to work independent of the crank, whereby the necessity of slamming the door is avoided; while, by the peculiar form of the follower and crank, a rolling instead of a rubbing motion is produced, which prevents friction, and conduces to durability.

We are not sufficiently acquainted with the "new substitute for marble, scagliola, &c.," shown in (20) by Mr. Bridell, to speak from experience as to its qualities, but on the opening night Mr. Ashpitel spoke of it as among the most important of the new inventions exhibited in the rooms. He considered that it would enable architects to put colour on walls, of a durable kind, at a cheaper rate than can at present be done in other imitations of marble, or polished coloured surfaces. It is made in slabs of various sizes ready for fixing on the walls, which do not require rendering. The slabs are perfectly straight and true, like marble itself, and are polished and enamelled in a permanent manner. The colours are embodied in the material as they are in scagliola. It is applied to lining and decorating walls, and is also manufactured in chimney-pieces, tabletops, and in every article that can be made of marble. Slabs are also made in self-colours of various tints, suitable for bath-rooms, conservatories, and for panelling dining-rooms, &c. The very handsome dining-room in the new wing of the Tavistock Hotel, Covent-garden, recently erected from the designs of Mr. Munt, architect, is lined and decorated with this patent marble. The price is, we understand, considerably under that of scagliola or enamelled slate, and it is applicable to purposes for which neither of those imitations of marble can be used; and taking into account its durability and cost, it may be considered to be cheaper ultimately than good graining.

In the lobby leading to the East Gallery are a few specimens of ornamental wood (21), in which the pattern is burnt in, being therefore indelible, and not subject to injury from the heat of the sun or from damp. Moon's register chimney door, and conical chimney-pot (22), appear to be well adapted for their respective purposes. The register is to be fixed at the commencement of the flue; the doors are placed underneath on runners, are easily regulated, and may be partially or entirely closed when the chimneys are not in use, preventing down-draughts or soot from entering the rooms. Mr. Moon suggests to architects and builders that a considerable improvement would be made in chimney construction at the upper part or shaft, by more completely separating the flues—that is, by having 9-inch divisions instead of 4-inch, which would prevent the flues interfering with each other, so that cowls and other deformities may be got rid of. A cast-iron label plate should be spiked on each flue. Top sweeping might be adopted by a light stage of iron, attached to the 9-inch division of flues. Every stack of chimneys should have a spare flue for ventilation from each story.

THE EMBANKMENT OF THE THAMES.

THIS great work, which has occupied public attention for some years past, and to which frequent reference will be found in our pages, will in all probability soon be commenced. The commission which was appointed relative to the matter have recently received numerous plans in reply to their advertisement, and are now engaged in the consideration of them; and the House of Commons, a few evenings back, postponed the second reading of the Thames Embankment Bill for a fortnight, in order that they might have the advantage of the result of their deliberations on this matter, which the formation of the low-level sewer has rendered an immediate necessity, for the construction of the sewer along the Strand would occasion such interruption to London traffic as to make it, commercially speaking, an impossibility.

On the question as to what line the embankment should take there seems to be no difference of opinion, the engineers examined by the committee adopting almost exactly the line known as Walker's line, being that laid down by Messrs. Walker and Burges, in their survey made in 1844, and extending from Westminster-bridge to Paul's-wharf, and in some of the plans to Southwark-bridge, below which the river narrows considerably. As to the form the embankment should take, however, and the mode of dealing with the foreshore, a variety of suggestions were submitted; but as we purpose to return to this matter on a future occasion, we do not at present intend to enter into the details of the schemes proposed.

Taking the results which the committee concluded would be obtained by the successful carrying out of a well-conceived method of embankment—viz., the improvement of the river, facilities for the construction of the low-level sewer, relief to the at present overcrowded streets, and increased facilities for carrying on the river-side trade, as the objects which all designs for this purpose should aim to accomplish, we propose in a future number to examine briefly the various plans which have from time to time been put forth, and to endeavour to give some suggestions useful for the work; premising only that to those objects as set forth by the committee we would add the architectural embellishment of the metropolis, and the securing of an open space along the river side which, if not in all cases equal to the present foreshore, shall at least be as large as it is possible to make it. We hope the grandeur of the work will not be sacrificed to a timid economy; while in these days, when the value of open spaces and fresh air is so well understood, it will need no argument from us to show how undesirable it would be to contract this great air-passage with high embankments and viaducts, or handsome terraces, however remunerative such might be. We are no advocates for a lavish expenditure, but we do hope that the question "Can it be made to pay?"—a most appropriate one in the case of a private enterprise—will never be asked in reference to this matter. Pay it certainly will, if well carried out; and in a much better, though less immediately appreciable sense, than if it brought in handsome dividends. What is required is a work that shall be a credit to the age, and, in a sanitary aspect, advantageous to the metropolis; an incalculable convenience to the traffic of London it cannot fail to be.

To these considerations we hope all prospects of remunerative returns from railways, tolls, shops, hotels, or warehouses, will be subordinated, and that the work, when completed, will be something very different from the ordinary style of engineering architecture, of which we have unfortunately so many specimens. The present opportunity is one which might be seized for the introduction of a comprehensive scheme for the improvement of the river-side property, as considerable alterations will be required in many instances by the construction of docks, while the great scope there is for improvement in nearly the whole of the buildings and premises along the shore would, in all probability, ensure the support of the parties immediately interested.

◆

GENERAL STATISTICS OF FRENCH RAILWAYS.*

The French railways completed to the 1st of January last occupy an area of upwards of 30,000 hectares (74,200 acres). More than 300 millions of francs have been expended in the purchase of properties.

The crossings of roads and footways are 11,500 in number, of which 5500 are level crossings, 4000 are under the rails, and 2000 over the rails. There are numerous other engineering works designed for the escape of water, such as aqueducts, archways, and bridges under 65 feet span. The wide bridges across water-courses have spans which, put together, amount to more than 30 kilometres. The tunnels form a length of 100 kilometres; out of 9076 kilometres worked at the commencement of 1860 the length of the lines with a single way was, at the utmost, 3600 kilometres. The way laid down in stations, and for traffic, turntables, switches, and crossings, may be estimated as having cost one milliard of francs, and the quantity of cast-iron consumed on them at 1,000,700,000 tons. The wood employed for sleepers and longitudinals is supposed to amount to 1,000,700,000 *stères* (cubic metres).

Besides guard-houses and watch-boxes built for the superintendence of the lines, the working of them has rendered necessary the construction of numerous edifices of very considerable importance. Twelve stations of a rank above first class are enumerated, among them are those of Paris, Lyons, Marseilles, Bordeaux. There are 130 stations of the first-class, including junctions, termini, and the stations in the principal cities or towns traversed. There remain 1058 additional stations, which may be divided into two classes, 200 of them falling into the second class, and 858 into the third.

The important stations include:—Buildings for the passenger-stations, with its dependencies and out-buildings, such as various sheltering places, courts, and barriers;—buildings for the goods-stations, platforms and sheds for loading and unloading, inclines, cranes, and drawbridges;—constructions for feeding the engines with water, pipes, reservoirs, water-cranes, and stationary-engines;—buildings for stores, for fuel, and for tools, engines-houses, carriage-houses, and sheds for plant;—shops for maintenance and repair, and manufactories for construction, of engines and carriages, their shafting and machinery, and stationary engines;—lastly, buildings for the use of *octroi* and customs, the offices of the different companies, stabling, and coach-houses.

The rolling stock comprises 3000 locomotives and tenders, 7000 passenger-carriages, and 60,000 trucks of various descriptions.

The length of the lines of rails conceded was in 1850 nearly 4000 kilometres, representing an outlay of about 7 milliards, at the rate of 425,000 francs per kilometre. Of this expense the state bears a share, amounting to about one-seventh.

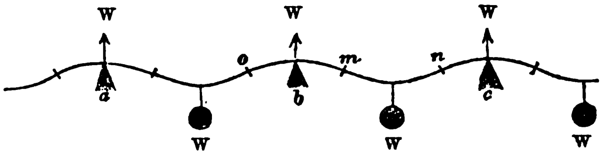
When the entire network is completed, all the departments will be crossed, and all the principal places communicated with, excepting only Mende and Digne. The principal ports will be in communication with the lines of rails, and the frontiers will be reached by twenty different lines. Belgium by seven, the German States by five, Switzerland by four, Italy by three, and Spain by one. The length of the railways opened for traffic on the 1st of January, 1860, was 9075 kilometres. Seventy-four departments were traversed, and sixty-five of the principal towns communicated with.

STRENGTH OF A BEAM FIXED AT BOTH ENDS.*

By Theo. Cooper, C.E.

The strength of such a beam, when loaded at the centre is stated by many to be, when compared with a similar beam *supported* at both ends, as 3 : 2. By theory, however, it should be as 4 : 2, or 2 : 1. In the case of a single beam, owing to the difficulty of perfectly fixing the ends, this theoretical result is not obtained; but there is a practical case in which we think it could be obtained, and would be of great importance,—that of a continuous beam extending over several points of support.

Let A B be such a beam, extending over several equidistant supports, *a*, *b*, *c*, &c., and loaded at the centre of the openings with weights, W. The reactions at *a*, *b*, *c*, &c. will also be equal to W, and the convex portions *o m* of the beam will be equal and similar to the concave portions *m n*; since both are acted upon by the same forces. Evidently at the sections *o*, *m*, *n*, of the beam there will be no strain of compression or extension; and were the beam separated at these points, and the parts suspended from each other, the relation of the forces in the beam would not be altered. This would divide the beam A B into a number of beams, with a length equal to one-half the opening *ab*, and supported at the ends. The strength of each of these, representing the strength of A B, would be twice that of separated beams spanning the openings *ab*, *bc*, &c.



We see moreover that the beam thus loaded would break at both the centre and supports simultaneously. If however we suppose the beam A B to be loaded uniformly over its whole length, the reaction then being greater than the force acting between the supports reduced to the centre, the relation of the forces will be different, and we shall have as follows:—Representing the strain at the centre of the opening by 1; that for the strain over the supports will be 2; and that for the centre of a detached beam of the same span will be 3. A beam thus loaded would break first over the supports, and then at the centre; and its strength would be to that of a supported beam of the same span and load as 3 : 2 (Moseley says as 3 : 1, but he assumes it to break at the centre.) The points *o*, *m*, *n*, will be at a distance of 0·26289 of the opening from the supports. This last case may be applied to a bridge continued over several piers, and supporting a distributed load, as a train of locomotives.

As we gain 50 per cent. in strength by thus continuing even a girder of uniform chords over the piers, we see the importance of considering these facts. And in proportioning the chords to the strains we would have very different results from the case of a single span; for in the parts *o m* of the girder, the position of the compressive and extensile forces would be the reverse of that for the parts *mn*; the chords should be the strongest over the piers, and decrease towards *o* and *m*, and then again increase to the centre, where the strength must be to that at the piers as 1 : 2. When only one span is loaded our assumption of a distributed load may still be considered as true, by making a proper application of a system of counter-braces, to prevent the uprising of the unloaded spans. When we have a girder extending over but two or three openings, our statements are subject to modification.

◆

THE NEW DISTRICT POST OFFICES OF LONDON.

Within the last three years, great improvements have been made in the postal system of the metropolis, which when completed will greatly accelerate the business of the department. Within a radius of three miles from the General Post-office, St. Martin's-le-Grand, several District Offices have been erected, and others are in progress or contemplated. Of those already erected and in operation, one is at the corner of Southampton-street, High Holborn; one at Islington; one at Bethnal-green; and another on the eastern side of Vere-street, Oxford-street; which latter, having inspected, and it being a type of the others, we will briefly describe.

---

* From *Nouvelles Annales de la Construction.*

* From the 'Journal of the Franklin Institute.'

The District Post-office in Vere-street stands upon an irregular site, extending 100 feet in depth to Chapel-place at the rear. The Vere-street front is faced with malm bricks, having cement-dressings to the windows, &c., and is 34 feet from centre to centre of the party-walls, and 50 feet high from the footpath to the top of the parapet. Beneath this level there are large and commodious basements, occupying the whole area of the site. The Chapel-place elevation is 55 feet in width.

The ground-floor is in two divisions, the Vere-street portion being occupied as the money-order office, with a clerks' private office at the back; and that extending to Chapel-place being appropriated to the sorting-room, public inquiry office, and entrance lobby.

The sorting-room is 57 ft. 6 in. long, by 46 feet wide, and 33 feet high from its floor to the upper part of the roof, from which it is lighted by louvres. One of the peculiarities of this room is its roof, which, instead of being supported by beams of timber of large scantling, is sustained by comparatively slender iron principals, by which there is no obstruction of light. On the centre of the floor are four sorting-tables, each having connected with it twenty "swing seats." These peculiar seats have circular tops, and work on a vertical crane-like pivot, and when not occupied are swung under the tables, thus leaving the avenues perfectly clear for traffic. The wall fittings comprise four double tables, arranged for stamping letters, and partly for sorting; and at the southern side of the room are the charge-taker's and registrar's offices. On the western side of the room is the comptroller's rostrum, which being elevated commands a perfect view of all the operations in progress over the whole area of the room. The ventilation of this department is effected by by side lights in the lantern, the lights being regulated at the floor level by turning a handle, by which any desired quantity of air can be admitted.

The basement is fitted up for the comfort and convenience of the *employés*. The drainage is unexceptionable; and the foundations rest on good concrete embedded on a dense gravel, and consequently the walls are perfectly dry. The supply of water is abundant; the lavatories are spacious, and supplied with spring taps for preventing waste; and the water-closets being constructed of slate and enamelled tiles, are durable and cleanly. On the Vere-street side there is a sorters' kitchen, and a small library well stocked with books and periodicals, for the special use of the men connected with the establishment; and at the rear is a kitchen of larger dimensions for the use of the large body of letter-carriers employed.

This structure altogether fully expresses its especial purpose without superfluous or unmeaning embellishment Mr. James Williams, of Whitehall-place, surveyor of post-offices to the Office of Works, furnished the designs, which have been satisfactorily carried out under his supervision by Mr. Stair Walker, the clerk of works. Mr. Hebb, of New North-road, Islington, was the contractor.

NOTES OF THE MONTH.

St. John's Church, Chester—During the restorations which have been recently carried on in this church, amongst other less important decorations, as tiles, &c., there was found on the removal of the whitewash from a shaft in the north-west corner, a figure representing the patron of the church, painted of the size of life, with the action of speaking or reading from a book borne in one hand; on the cover of the volume is represented a lamb, symbolic of Jesus Crucified, with the red-cross banner and the cross on the head of the staff, denoting the Resurrection. Some of the ancient gilding remains upon the nimbus surrounding this. The background represents a city, probably Chester, with Norman towers, and a woodland with deer.

Westminster Street Railway.—On the 15th ult. Mr. Train opened the second portion of a line from Victoria Station to Westminster Abbey, about a mile in length. Another line is commenced from Westminster-bridge to Kennington-oval; and as it will probably not be difficult to take the Westminster cars across Westminster-bridge, where tramways already exist, the public will get a useful line of some length. The vestry of Islington have given Mr. Train permission to lay down his railway from the end of King-street, Lower-road, to the bridge in New North-road.

The Bank of England.—The stone employed in the building of the exterior of the Bank of England has manifested evidence of a rapid decay; of a character similar to that in the stone of the New Houses of Parliament. With a view to arrest the progress of the decomposition a coating of a newly-invented composition is now, by way of experiment, in course of being applied to the surface of that portion of the building in Threadneedle-street fronting the Royal Exchange, where the principal entrance is situated. The buildings of the establishment of the Bank of England were erected in 1732, enlarged in 1771, improved in 1796, and partly rebuilt in 1824.

Inventors and the Exhibition of 1862.—In 1851, before the passage of the Patent Law Amendment Act, "The Protection of Inventions' Act" was passed, to enable inventors to exhibit their inventions in the Great Exhibition without prejudicing their rights to secure a patent afterwards. No fees were required under this act, and about 600 inventors availed themselves of the privilege which it afforded. The commissioners of the approaching exhibition, having had the matter under consideration, have concluded that no similar protection will be again required, the present patent law being adequate to all needful protection, and at very moderate cost.

Photo-Zincography.—Mr. Gladstone, a short time ago, says the *Athenæum*, consulted Sir Henry James on the possibility of copying our ancient records by means of his process of photozincography. A small deed of the date of Edward I. was copied and printed with so much success, and at so trifling an expense, that Lord Herbert of Lea, the Secretary-at-War, ordered the impressions to be bound up with the yearly report on the Ordnance Survey. Thus encouraged, Sir Henry James got permission from the Lords of the Treasury to copy that part of the Doomsday Book which relates to Cornwall, as an experiment. He has now achieved this commission, with a result which should certainly encourage the further prosecution of the design, county by county, as appears to have been originally proposed by him. Those who care to have no more of Doomsday Book on their shelves than relates to their own shire can buy the local part; those who wish to have the whole can bind the several parts into volumes. The work is to be published, we believe, at cost price, or nearly so.

The Chapel Royal in the Savoy.—The restoration of the ancient Chapel Royal in the Savoy, which is in connection with the Duchy of Lancaster, is in every way complete, and has just been re-opened for worship. The beautiful heraldic devices on the ceiling have been brought out with great effect, and are perhaps the finest specimens of such works of art in the kingdom. For a long series of years they were hidden under repeated coats of whitewash, but in 1843 Mr. John Cochrane, a bookseller in the Strand, having been appointed chapel-warden, brought his antiquarian knowledge to bear on the neglected ceiling. His exertions were rewarded by the discovery of these exquisite devices, which from the south to the centre are those of the Houses of York and Lancaster, while those from the centre to the north represent various incidents connected with the Cross and Passion of the Saviour. Two new panels and several pipes have been added to the organ. One or two modern monuments at the south end, which were injured by the fire, have been restored; all the ancient monuments at the north end were fortunately uninjured.

Dwellings for Working Men at Leeds.—An experiment, of considerable social interest, has just been commenced at Leeds, to provide model cottages suitable for working men. The promoters of the scheme are anxious that the better class of working people should possess houses of their own; and the society now organised proposes to hand over a cottage to a proper applicant on payment of £25 in cash, and the weekly sum of 5*s*. during thirteen years. It has been decided to erect ten houses, each having a garden in front and a yard and outbuildings at the rear. Mr. Ambler, architect, has made the design, which is Elizabethan. On the ground-floor will be a parlour, 15 ft. 2 in. by 11 ft. 6 in.; and kitchen, 15 ft. 2 in. by 12 feet. On the floor above are three bedrooms, having separate doors, the front one same size as the parlour. The staircase runs from the kitchen. The cost, including land and mortgage, is not to exceed £150 on each house. This is an excellent scheme. If the cottages now commenced are taken up by the class for whom they are intended, the movement is to be at once extended, and a number of cheaper cottages built on a similar principle.

LENDAL BRIDGE, OVER THE OUSE, YORK. W. DREDGE. C.E.

Details of Girders.

Fig. 1.

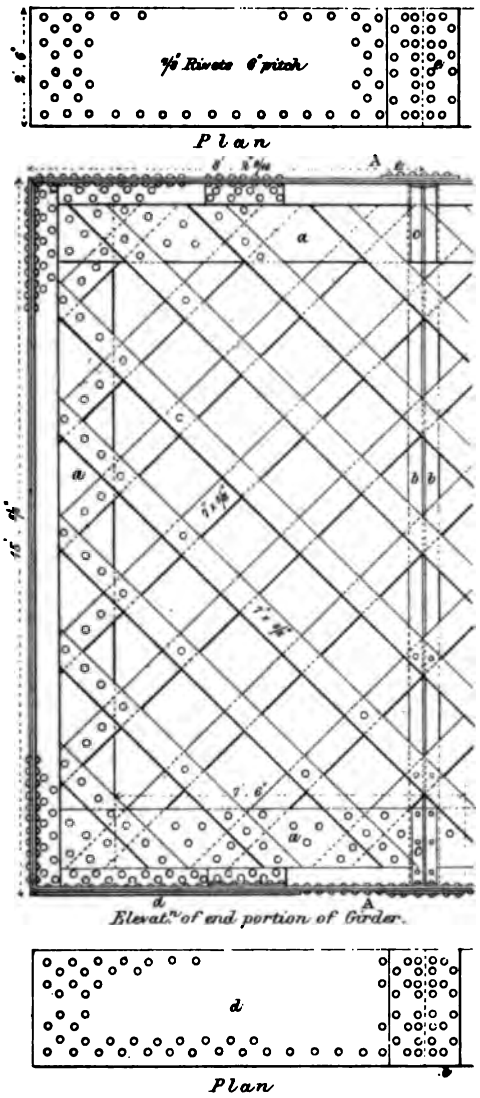


Fig. 2.

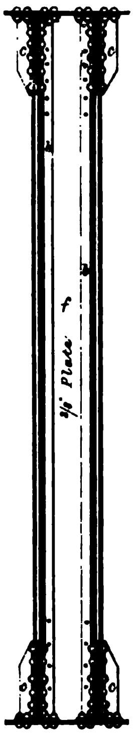


Fig. 3.

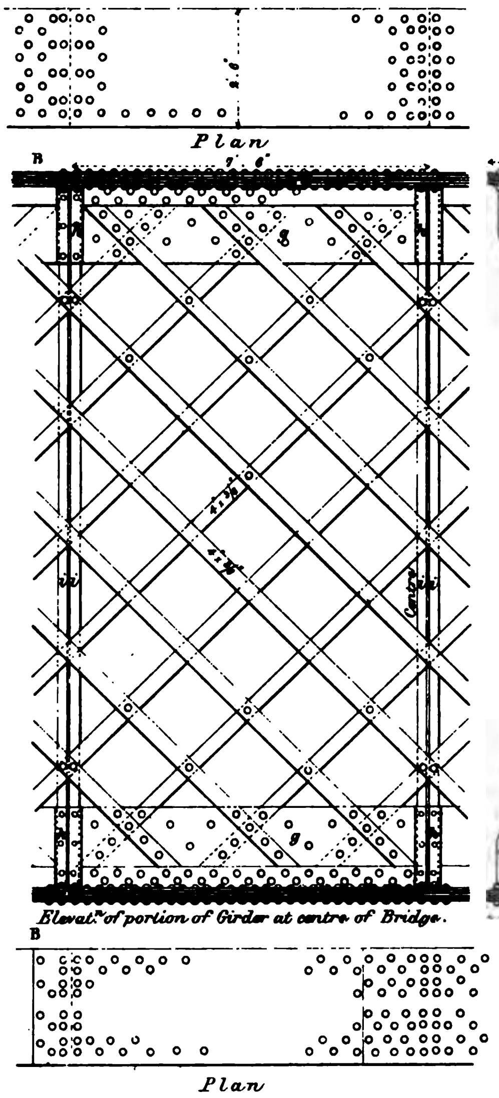


Fig. 4.

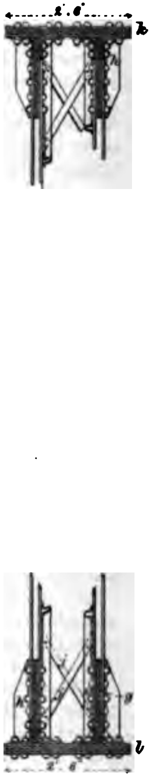
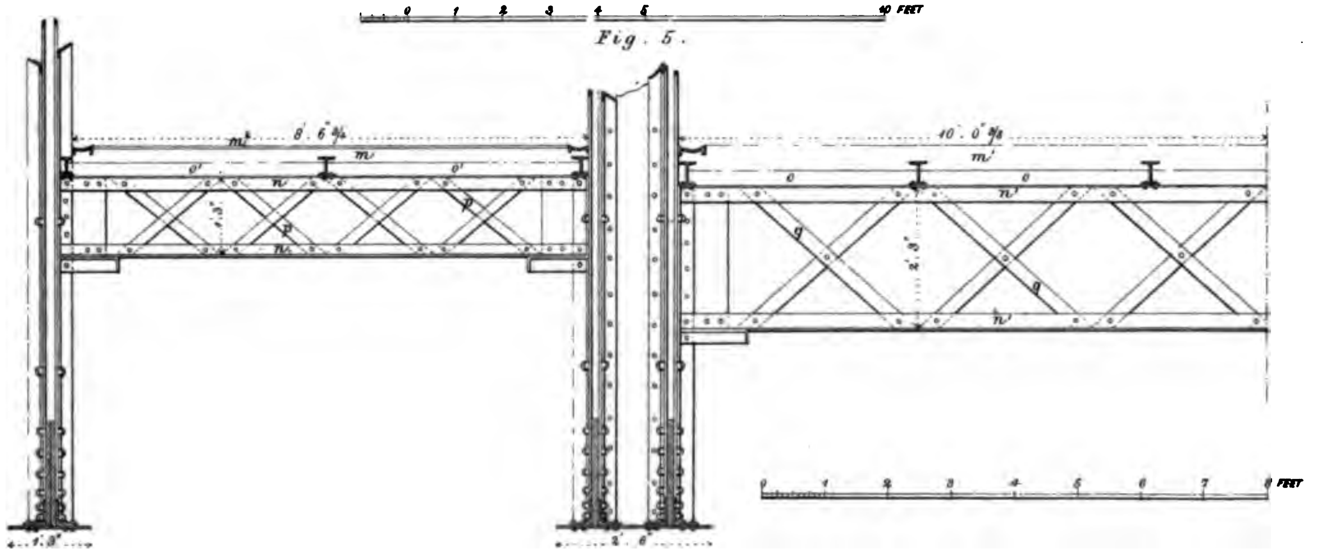
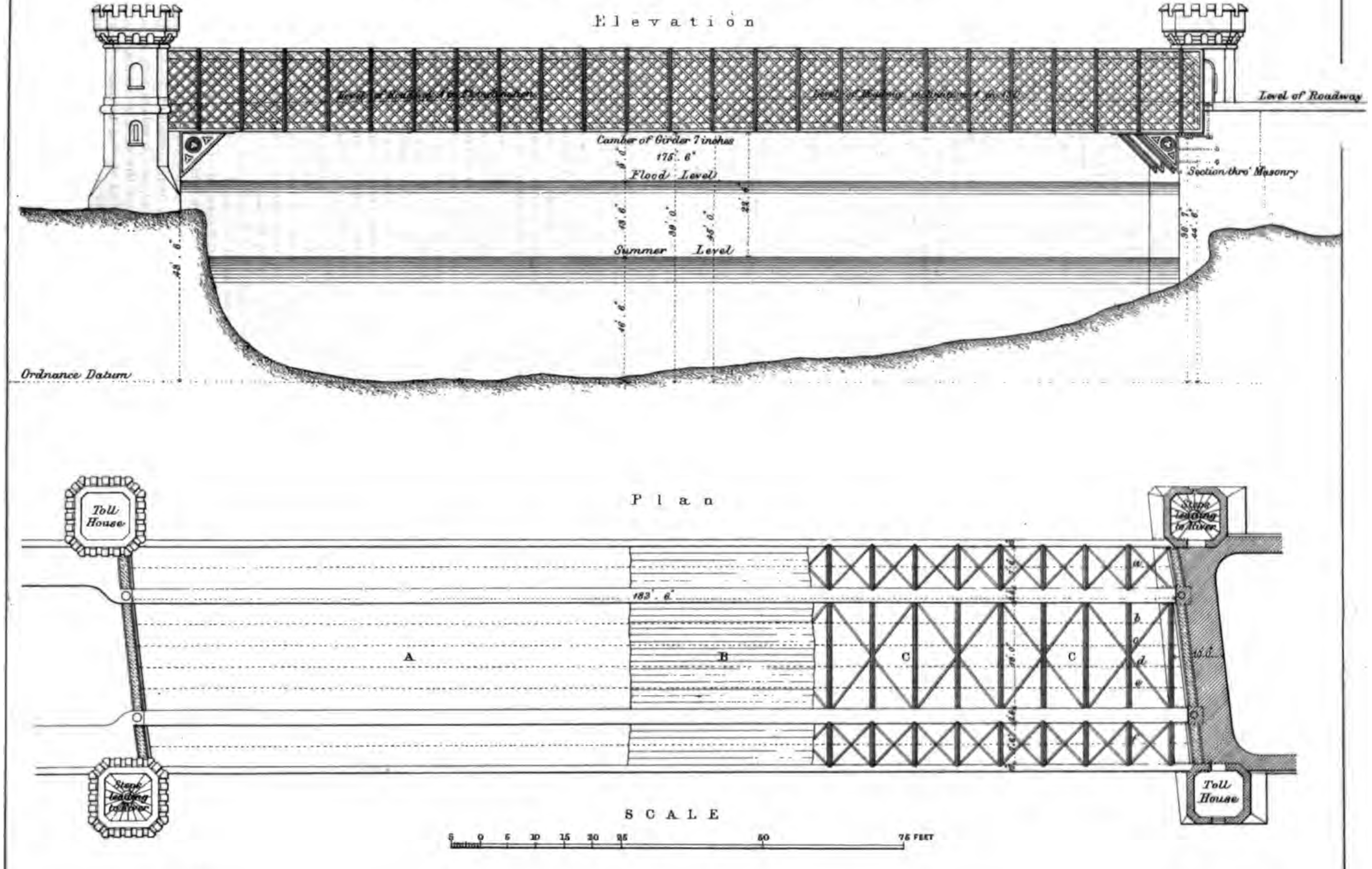


Fig. 5.



J.R Jobbins

LENDAL BRIDGE, OVER THE OUSE, YORK. W. DREDGE. C.E.



J.R. Jobbins

LENDAL BRIDGE, YORK.

(*With Engravings.*)

The iron girder bridge of which we give illustrations in Plates XVII. and XVIII. is now being erected from the designs of Mr. Dredge, C.E., across the river Ouse, at Lendal Ferry, York. It crosses the river at an angle of 84 degrees, and has a clear span of 175 ft. 6 in. The width of the bridge is 41 ft. 6 in., divided into two footways each 7 ft. 6 in., and a central carriageway of 19 feet, making in all 34 feet, the remaining 7 ft. 6 in. being occupied by the width of the girders.

The approach walls are of brick and the abutments of masonry, built on piled foundations. The bearing piles are driven about 28 ft. in the gravel; they are 13 in. by 13 in., and spaced 3 ft. apart, measured from centre to centre; there are 160 of these piles under each abutment, and they are surrounded with sheet piles. Within the sheet piling and between the bearing piles the ground is excavated to the depth of about 10 feet below summer level of the water; and the space so excavated up to about 6 feet below the same level is filled with concrete. The bearing piles are cut off at this level, and York landings laid thereon, upon which the masonry of the abutments is built.

The girders are each 183 ft. 6 in. long and 15 feet deep. The roadway is constructed within the girders at the level indicated in the elevation, Plate XVII. The headway between the summer level of the river and the underside of the girders is 22 ft. 6 in. The girders are constructed with top and bottom members of plate and angle irons, connected with a web of lattice-bars at an angle of 45°, strongly rivetted to top and bottom members. At a distance of 7 ft. 6 in. apart, measuring along the entire length of the girders, vertical stiffening plates are fixed, for the purpose of giving lateral stiffness on both sides of the girders, as shown in the elevation. The ends of girders are finished off with vertical plates and angle-bars of the section of top member, upon rollers on bed plates, having a bearing of 4 feet on each side. The two central large girders are each constructed of two girders precisely the same as those just described, and connected both at top and bottom members by covering plates 30 inches wide, as shown in the plan: the interior vertical stiffening plates being connected by diagonal bracings. The bed-plates upon which the girders rest, lay upon the abutments and are secured thereto, those beneath the central girders are 8 feet by 5, and the outside one 8 feet by 3 ft. 6 in. These bed-plates are of cast-iron 2½ inches thick, having the surface planed, upon which are placed the roller-frames, each containing eight 4-inch steel rollers, turned, and which carry the main girders of the bridge.

The footway girders are braced to the large girders by strong horizontal and diagonal bracing, rivetted to top member, as shown in Fig. 5, Pl. XVIII.; similar bracing being also attached to the bottom flanges. The two large girders are also similarly connected and braced at the level of the bottom flange, as seen in Fig. 5.

Both carriage and foot-ways are carried upon wrought-iron cross-girders, spaced 3 ft. 9. in. apart, and secured at the ends to the principal girders. A covering of corrugated plate rests upon the top flange of cross-girders, and is secured thereto; the plates for the carriageway being ⅜-inch thick, those for the footway ¼-inch thick. Gutters are laid along the side of the carriageway and footways for drainage, which run towards the North-street abutment and are then carried down pipes.

The carriageway is formed by laying a concrete of cement and gravel about 3 inches thick over the corrugated plates, which concrete is covered with 4 inches of road-metal. The footpaths are formed with 2 inches of similar concrete, covered with 1 inch of asphalte. At the ends of the roadway girders lamps are erected in the positions shown on the plan. At each end of the bridge gates are fixed, and made when open to fold within the girders.

The approach road across the opening opposite the North-street postern is carried by eleven light iron girders, 1 ft. 5 in. deep, placed 4 feet apart, and resting upon the side walls, the corrugated plates ⅜-inch thick resting upon the top flanges, and rivetted thereto. Diagonal bracing is introduced beneath the roadway to give lateral stiffness. A light cast-iron rail is fixed on each side of the bridge. The carriageway and footway are formed of concrete and road-metal, as described for the carriageway and footway of the bridge. The weight of iron in the bridge is about 450 tons. The cost, including the abutments and approaches, is estimated at £17,500.

As stated above, Mr. Dredge is the engineer of the bridge, and it is now being executed under the immediate superintendence of Mr. Pickersgill, city surveyor, York. Messrs. Calvert, of York, are the contractors for the ironwork.

References to Illustrations.

Plate XVII.—Elevation and Plan.

A. General plan, showing roadway and footways.
B. Portion of bridge with road-metalling removed to show the corrugated plates.
CC. Exhibits the bracing and cross-girders, with corrugated plates and road-metalling removed.
The dotted lines *a*, *b*, *c*, *d*, *e*, *f*, on plan represent central lines of bearers of the corrugated plates.

Plate XVIII.—Details of Large Road Girders, &c.

Fig. 1.—Elevation of portion of girder at bearing, and plans of top and bottom members of ditto.

a, *a*, *a*, Double vertical plates, 20 in. by ⅜ in.
b, Two angle irons, 3½ in. by 3½ in. by ½ in.
c, *c*, T-irons, 6 in. by 4 in. by ½ in.
d, *d*, Bearing plate of puddled steel. 4 ft. 3 in. by 2 ft. 6 in. by 1 in.
e, *e*, Cover plates, 2 ft. 6 in. by 1 ft. 6 in. by ½ in.

Fig. 2.—Section of portion of girder taken at AA Fig. 1.

f, *f*, Plate ⅜-inch.

Fig. 3.—Elevation of portion of girder at centre of bridge, and plans of top and bottom members of ditto.

g, *g*, Triple vertical plate, 20 in by ⅜ in.
h, *h*, T-irons, same as in Fig. 1.
i, *i*, Two angle-irons, 2½ in. by 2 in. by ⅜ in.

Fig. 4.—Section of portion of girder taken at BB Fig. 3.

j, *j*, Lattice bars, 1½ in. by ⅜ in.
k, Four plates, 2 ft. 6 in. by ½ in.
l, Four plates, 2 ft. 6 in. by ⅜ in.

Fig. 5.—Transverse section of half of bridge, showing one footway and half of roadway.

m, Concreted footway.
m 1, Road-metal.
m 2, Asphalte, 1 in. thick.
n, *n*, Angle-irons, 2½ in. by 2½ in. by ⅜ in.
n′, *n′*, Ditto, 3 in. by 3 in. by ⅜ in.
o, *o*, Corrugated plates, 3 ft. 10¾ in. by ¼ in.
o′ *o′*, Ditto, 4 ft. 1⅜ in. by ⅛ in.
p, *p*, Angle bars, 2 in. by ⅜ in.
q, *q*, Ditto, 3 in. by ½ in.

◆

ARCHITECTURE AT THE ROYAL ACADEMY.

During the past twelvemonth considerable alterations have been made in the internal arrangements of the National Gallery in Trafalgar-square, alterations which have before been adverted to in our current notices,* and which materially affect the space allotted for the exhibition of the national collection of pictures, and that devoted to the annual exhibition of the Royal Academy. It will suffice therefore briefly to recapitulate that the whole of the centre of the building has been remodelled, the two handsome staircases constituting the respective approaches, with their divisional screen of columns, being entirely swept away, thus destroying the unique and most successful architectural effect in the whole building, the only misfortune of which was that it occupied, perhaps, too much room in so limited an area; the old Sculpture Room, so small and gloomy, has given place to a more ample one, but with too much light, or rather with too many openings, since there is far too much reflected light to show the objects properly; while over this room, and by taking in a portion of the old staircase, an important addition is made to the National Gallery, in the shape of an entirely new and well adapted room, of spacious proportions, which with the other modifications has been very skilfully carried out by Mr. Pennethorne. As may be expected, the half till lately occupied by the Royal Academy has suffered much by these encroachments, so that it is now high time that for its own sake it shifted its quarters to Burlington House, or somewhere else where its requirements may be better met, and without trespassing longer on space that can so ill be spared.

The access to the Academy exhibition is by the former entrance under the principal portico, whence the visitor enters the now meagre and unarchitectural lobby (for it does not deserve the title of *hall*), and immediately finds himself at the foot of a narrow awkwardly-contrived staircase, which ushers him, without ceremony, at once into the first of the suite of rooms,—in fact, the original "Miniature Room," as it was termed. It will be remembered that, in the former arrangement, the passage or corridor separated this room from one opposite of corresponding size, known of yore as the "Architectural Room," but more recently as the "North Room." But the aforesaid corridor no longer exists, its space being thrown into the North Room and one beyond. This change has involved, of course, new ceilings and lighting, while, on the score of comfort for exhibition purposes, it is certainly an improvement.

---

* See *C. E. & A. Journal*, vol. xxiii. p. 249.

The Sculpture Room is, as we have intimated, considerably enlarged, and so planned as to give the appearance of three apartments with one common approach, not of the most elegant kind, being, literally, down two or three steps round a dark corner.

In the now enlarged North Room the architectural drawings find their sole locality, and even this is more than twice as large as either the drawings submitted were deemed worthy to occupy, or the space which the Academy "hangers" agreed to devote. The number of architectural works thus exhibited is only between sixty and seventy; nor is their want of numbers redeemed by super-excellence of quality, for, both as regards the subjects themselves, and as specimens of art delineation, they are by no means equal to those of last year. Added to this, we observe that the R.A. architects are entirely unrepresented, excepting Mr. Scott (who has since the last season attained to full honours), and the new Associate, Mr. E. M. Barry; and the contributions of these two gentlemen are among the most conspicuous, as well as meritorious, in the room.

To commence our more deliberate survey: the first three pictures being hung actually above the door suggests our protesting, as we are from year to year compelled to do, against the absurd —not to say unfair—practice of placing works of this class at such a height above the eye that it is next to impossible, even with the most persevering scrutiny, to arrive at anything like an adequate conception of what they are intended to convey. We shall have to endorse our comments on many a promising picture with this drawback, and must condole with their authors under such treatment: but, possibly, out of the evil good may come; and since the Academy seems to hold our noble professson in such light esteem, the Architectural Exhibition *per se*, in Conduit-street, may thrive through this neglect—and we heartily wish it may do so, though there are abundance of reasons why the two should pursue, with increasing vigour, an uninterrupted course of prosperity, since each has its special claims, its speciality of purpose, and its special means of diffusing an acquaintance with and taste for the art.

Granting for a moment that certain pictures are to have this lofty destination, there are not any works more telling at a distance than those of Mr. R. W. Billings, whose name inaugurates the architectural list, and who, in (654 and 656), gives views of parts of the extensive alterations he is now making in Dalzell Castle. Mr. Hamilton, the distinguished owner of the mansion, may be congratulated on having secured the professional services of an architect who, beyond all others, is conversant with the Baronial Antiquities of Scotland, and who adds to this knowledge a facility of design and contrivance which gives the stamp at least of originality and fitness, which is quite refreshing in these days of precedent and plagiarism. As Mr. Billings revels in mastering difficulties of all kinds, and there were doubtless some in designing the works before us, key-plans would not have been unserviceable, and, had they been supplied, it is just possible that the drawings themselves might have found a more covetable place. As it is, we see the rugged outlines, massive corbelling, and round turrets, inseparable from Scottish architecture, as salient points in the design, and distributed with a skilful hand, having an eye to the markedly picturesque as well as the useful. No. 655 (which suffers by its position between the two drawings just named, as well as its being also over the door) professes to illustrate, in "Villas erected at Roupell-park," the new mode of *half-timbered construction*, as practised by the architect, Mr. Taylor, jun. In a such a position it is absolutely impossible to examine the diagrams, and we are not sufficiently acquainted with the practical results of this method to offer any opinion on its expediency.

"Duncrub Castle, near Perth," now erecting by Mr. Habershon (657), is another of the many Scottish mansions we see delineated around, and apparently among the most important. In our opinion it has the fault of not being sufficiently in keeping with either a castellated edifice or the bold uncompromising characteristics of the country itself. A more successful composition of this kind is (661), "Additions to Killyleagh Castle," by Mr. Ferrey, but even this, in spite of its battering walls, and orthodox looking gateway, lacks much of the nerve and feeling of that genuine ancient work which it too feebly imitates. The castle itself (which is here seen within the new inclosing wall), is we presume an old one; it certainly appears to have that character in a very satisfactory degree. Mr. Ferrey also exhibits two other residences, "Bulstrode, a seat of the Duke of Somerset" (693), which is very common-place Gothic, and "Wynnstay House" (705), now erecting for Sir Watkin W. Wynn, which, beyond its extent, has little to recommend it; both are excessively tame, and unworthy of the author's name and reputation. Nor can we much commend Mr. Kempson's design for the "Hereford Clock Tower" (659), of which competition so goodly an array of designs may be seen in the Conduit-street galleries. It consists of a square tower, of campanile proportions, but treated in the more ornate style of Gothic, with an octagonal staircase at one angle, which is continued up to the top. The whole is capped by a dwarfish spire, rising behind the parapet.

The "Interior of Grand Staircase" in Mr. Dickson's new mansion at Gottenburg, Sweden (662), now being erected by Mr. W. A. Boulnois, is a very beautiful Classic design. There is abundance of space, so that scope is afforded for a thorough architectural composition, in which piers with semi-circular arches constitute the most prominent feature. These act as a screen from the corridor behind—a not uncommon arrangement on the whole, but susceptible of considerable variety, according to the fancy of the designer. In the view before us the introduction of sculptured panels here and there is of great service, as is also the value of colour, as indicated by the Sienna scagliola and other marbles, while additional brilliancy is imparted by the sparkling design of the brass (or gilt?) railing. There is however one portion which seems hardly in keeping with the rest—viz. the plain, flat, shallow skylight, but this is a matter that will perhaps suggest itself for reconsideration. The execution of the picture is unusually good. Mr. H. Clutton's "Interior of the New Chapel" in the Roman Catholic church, at Farm-street, London (663), and Mr. Bentley's "Study for a Chancel" (671), may pass almost under the same comments, so all but identical are they in design. Both are decidedly most praiseworthy deviations from the beaten track, and, making every allowance for the powerful colouring of the architectural artist, afford a refreshing field of study. The chancel arch in each is similarly composed, and its inner rim springs from coupled corbel shafts of marble, which, with the parts adjoining, produce a a very handsome effect. Marble shafts and arcade work are also liberally employed on the wall surfaces generally, but the most peculiar exception is in the omission of the window which by all but universal consent should occupy the east end. In these two drawings, however, it is entirely wanting, the place being filled with a blank arcade of a centre and two half trefoil arches, their receding surfaces as well as the rest of the uncarved walling being enriched with figure subjects in fresco. Colour is, in truth, the predominant element in the designs, and scattered with lavish exuberance; but while we cannot but admire the skill which has so harmoniously blended the most brilliant, and we might say gaudy hues, we must repeat our regret at finding it so frequently made the chief instead of a subservient element in designs.

Among the street improvements for London, none would be more welcome than a satisfactory solution of the difficulty of Holborn-hill. Many schemes are, as our readers know, afloat, proving the desirableness of something definite being arrived at; while Victoria-street and the contemplated openings northward, which will bring in so large an amount of extra traffic, would seem to necessitate some practical solution of the question ere long. In (664, 672) Mr. F. Marrable, the late architect to the Board of Works, submits an elaborate scheme, in certain respects not unlike some which have heretofore been brought before the public, and which appears calculated to accomplish the object perfectly. Half of the roadway is proposed to be raised (to a level, we presume) between St. Sepulchre's Church and Hatton-garden, forming a viaduct, with a series of shops gained in the difference between the height of the present and contemplated levels, while Victoria-street would be spanned by an elliptical iron girder bridge. The two drawings now exhibited show what would be the general effect, as viewed respectively from Snow-hill to Hatton-garden and *vice versâ*. Bronzed sculpture is introduced on pedestals terminating the balustrades of the roadway.

(665) "The Beauchamp Almshouses, to be erected at Newland, near Malvern," by Mr. P. C. Hardwick, form an extensive range, planned so as to make three sides of a quadrangle, with additional

return buildings as wings. In the centre of the principal front is the gateway, which very properly distinguishes itself as such; while immediately contiguous, on the right, is the chapel, which by-the-bye has a chancel, and is otherwise quite ecclesiastical in character, besides being built of stone, while the almshouses generally are of red brick with white dressings. We are glad to notice the snugness of the sheltered doorways, so conducive to the comfort of the inmates. "Bodelwyddan Church," near St. Asaph, by Mr. Gibson, and of which a large and showy interior of the chancel is given in (667), is known as one of the costliest and most elaborate of modern churches, and, it having been frequently illustrated of late, is doubtless already too familiar to our readers to need describing again. We should be glad to be able to speak in terms of recommendation of Mr. G. S. Clarke's "Blind Asylum, Brighton" (668), but the skill which that gentleman usually exerts in his domestic buildings appears to have failed him here. With the shape of its outline perhaps we ought not to quarrel, as that might have been imposed by circumstances, but surely Mr. Clarke could have given us something more agreeable in the shape of windows than a repeated repetition of the everlasting Ducal Palace windows at Venice. The whole design has a commonplace look, from which the best of careful details is not likely to extricate it. Messrs. W. and A. Moseley, in their "Hotel at Liverpool" (670), have apparently succeeded in producing a clever Italian design, not altogether dissimilar from the New Westminster Palace Hotel, though of course on a smaller scale; but the picture being hung above the line, and withal being diminutive in its parts, it is impossible to allude to it more critically here.

(*To be concluded in our next.*)

THE EMBANKMENT OF THE THAMES.

SINCE we referred to this subject in our last number, the Royal Commissioners have been busily engaged in the consideration of the various plans submitted to them for this undertaking. The labour has been considerable, upwards of fifty different plans having been sent in, many of them accompanied by models and elaborately executed views; while the author of each design has had full opportunity of explaining verbally its arrangements in detail to the commissioners. We shall look anxiously for the result of the investigations of the commissioners, and hope that at last this long-talked-of but as yet unattempted work will be efficiently carried out. Of the various metropolitan improvements which have from time to time been suggested, there seems to us not one more obviously needed than this; and yet by some strange fatality it has hardly ever got beyond the suggestive stage, except when (in 1844) government took up the matter, and appointed commissioners upon the subject, who, after the examination of sundry schemes and the preparation of a most valuable and elaborate report,* finally recommended a modification of that designed by Mr. Page—and there the matter ended. May the labours of the present commissioners have a more substantial result.

The various plans now submitted may be divided into those which provide an embankment detached from the present shore, with either separate docks or a canal between, and those which merely propose an extension of the present shore further into the river. Besides these, schemes have been submitted for forming tidal dams, in one case at Blackwall Reach and in the other at London-bridge, and for the construction of a navigable cut from Battersea to Limehouse, communicating with the river at these points by locks; and converting that part of the Thames lying between the extremities of the cut into a large lake.

In the detail of what may be termed the supplementary part of the designs, affecting especially the remunerative character of the various plans, such as the provision for warehouses and other buildings, a great variety exists; though into this part of the question it is hardly necessary to enter, as all designs of the same character admit of the same modifications, while such considerations are of course secondary to the important ones of affording convenience to the traffic and improving the navigation of the river.

The navigation of the river being similarly affected by the detached and attached embankments, the first question to be considered is the affording facilities to the river-side traffic. And we think that this point is one deserving of more consideration than many of the competitors appear to have given to it: indeed, in some instances considerable interference with this trade is admitted to be a necessary accompaniment of the particular scheme; while, to our thinking, one of the very greatest recommendations which any plan could possess would be the diminution of the cost of landing and warehousing goods. The river carrying-trade is a most important one, and as much deserving of encouragement, and as capable of proportional development as that of our thoroughfares.

The advocates of detached embankments with docks—amongst whom are to be found Mr. Page, Messrs. Fowler, Fulton, and Hemans, Mr. Rendel, Mr. Bazalgette, Mr. Bird, &c.—would by their plans secure access to the docks for several hours at each tide, while the vessels, being kept always afloat, would have every facility for loading and unloading. Any person who has observed the great amount of labour in unloading barges, in consequence of the present state of the foreshore, will be at once struck with the great advantages of this arrangement. At present the barges lie stranded in front of the wharves for several hours at each tide, and the load has to be carried by men across planks for a very considerable distance. One of the most important features in the new arrangement, it will therefore be at once evident, is that of a *direct hoist* from the barges to the warehouses, and thence into the already-existing streets. This would certainly appear to be more perfectly provided by the plans with the detached embankments and docks, than by those which attach the embankment to the present shores: the warehouses rising from the water's edge, and direct hoists being obtainable to every floor, while the goods can be as readily transferred from the warehouses into waggons in the existing streets behind them. In the case of those plans which merely propose an extension of the present foreshore into the river, these advantages do not appear to be so fully secured. They all, with we believe but one exception, provide for barges floating to the sides of the quay at all times of the tide; but it will be at once evident that there cannot be a direct hoist to all the floors of the adjacent warehouses, as the goods must pass either under or over the embankment roadway. The barges in some cases lie six or seven deep alongside the wharf, and the difficulty of mooring, or, when loaded or unloaded, of shifting them from the quay side while lying in the open river exposed to the swell of the steamers, will be at once observable.

The opponents of the detached embankment contend that the docks can only be used at certain times at each tide; but taking into consideration that the bulk of the traffic is ascending and descending the river during a great portion of each tide, it would appear that this objection is not really of so much weight as at first sight it seems to be. It is however of the utmost importance that free access to the docks should be obtained for as long a period as possible at each tide; and while, to our thinking, this requirement presents an insuperable barrier to the adoption of lock entrances, it will no doubt have great weight in determining the position of the low-level sewer. The formation of the sewer in the embankment would be the most economical, as the solid mass surrounding it would prevent the possibility of disruption; but, by thus carrying it across the entrances to the docks, the depth of water at those points must be considerably diminished. Let the sewer however be placed on the land side of the docks, and there need be but slight limitation to the time during which access can be obtained to them. One thing however we think is very certain, that there can be no proper construction of the main sewer along the land side of the docks without an entire remodelling of the present wharf frontages, as mentioned in our May number: though, should it be considered that such an interference would be prejudicial to the scheme, it might, as has been suggested, be constructed without any interference with the property along the shore, in a solid embankment or quay outside and immediately in front of the existing wharves and warehouses; the sewer would thus be more accessible than if it were carried below the water in the docks; while the only impediment to the approach of barges from the river to the docks at certain times of the tide would thus be removed. A direct hoist to all the floors of the warehouses would be obtainable by this arrangement at the option of the owners, by simply bringing forward the first and upper floors to the face of the quay wall. These projecting floors would be supported by iron columns, forming on the ground floor an open colonnade or covered quay.

A most ingenious method of constructing the sewer has been devised by Mr. Page, which we will give in his own words, merely premising that he proposes to imbed the circular sewer in a mass of concrete: he says—"I should suggest that the lower half of the circle should be formed of concrete made of Portland cement and gravel; that the excavation being formed with sloped sides, a semicircular iron mould should be slung and fixed at the proper height, of a diameter 18 inches greater than the finished sewer, to allow of a lining of very hard bricks. This mould or inverted centre being in place, the concrete would be shot in on both sides, and the lower half of the structure rapidly completed, the 9-inch lining formed, and the remainder of the sewer, the sides and crown above the centre, built in brickwork."

---

* See *C. E. & A. Journal*, vol. vii. (1844), page 158.

The level of the roadway will of course be mainly determined by the headway to be provided at the entrances to the docks. We think however it will be found that the only barges requiring great height are those loaded with hay and straw; and it is a question well worth consideration at such a time as this, with the recollection of the recent disastrous fire at the wharf near Cannon-row, whether traffic in such a dangerously combustible commodity should be permitted on the Middlesex shore, in the midst of so dense a mass of buildings. The ordinary masted barges could of course lower their masts in passing under the roadway. It is to be hoped that the embankment will be kept as nearly as possible at the same level throughout, and that the symmetry of the work and the convenience of the traffic will not be impaired by any undue requirements on the part of the honourable societies of the Temple, or other private interests.

Much has been said in favour of the construction of a railway along the river side: if it be constructed we hope it will be kept below the general level, as suggested by Mr. Page, Mr. Bird, Mr. Brooks, and others; though it appears probable that, with the facilities afforded by the railways now in progress, there will be no urgent necessity for one; and we think a tramway far better adapted in this instance to the purposes of the passenger traffic.

We must not omit to notice several ingenious plans for forming the embankment in connection with the present shore, submitted by Mr. Shields, Mr. Turner (of Dublin), Mr. Walmsley, Mr. H. G. Coombs, Mr. Brooks, Mr. Gohns, and others. Mr. Turner's plans are accompanied by some very tastefully-designed warehouse frontages. We purpose in our next number to give drawings and descriptions of some of the principal schemes which have been submitted—this we had hoped to have done in the present number, but have been compelled to postpone it in consequence of the lateness of the period at which we received some of the necessary information.

BUILDING MATERIALS, INVENTIONS, &c. AT THE ARCHITECTURAL EXHIBITION.

SECOND NOTICE.

We conclude our remarks on this department by noticing a few of the remaining works which the pressure on our space last month compelled us to postpone.

Several excellent specimens of sculpture will be observed in different parts of the rooms, but none perhaps is better than the figure of St. John the Evangelist, which stands on a foliated stone bracket against the pilaster of the great gallery (199), and is by Messrs. Swales and Grassby. So also, in another style of art, the model of a font executed in statuary marble by Mr. J. Forsyth, for Whitley Church (138), is deserving of much praise. The group of angels supporting the bowl is a good idea, and charmingly carried out. Of models in plaster we may point to those exhibited by Mr. Phyffers (213), as executed under the direction of Messrs. Hardwick, Teulon, H. Clutton, and Burges. Of these, the monument to Lady Suffield, executed in alabaster, from the designs of the latter architect, is a beautiful composition, displaying unusual skill.

Messrs. Jackson's carton-pierre and papier-mache ornaments have been so long approvingly tested by the public that it is needless to advert to them in detail; but we may draw attention to the very beautiful door-cap frieze, as introduced in the sumptuous decorations at Clothworkers'-hall (209). In Mediæval Metalwork the show is very superior, especially the contributions of Messrs. Hart and Son, who have a goodly array, and of Messrs. Johnston, who exhibit several articles excellently designed by Mr. G. Truefitt. Messrs. Cox and Son again contribute church furniture and specimens of their excellent wood-carving.

Specimens of paperhangings are not so abundant as in previous years, but those by Messrs. Scott, Cuthbertson, and Co. (210), show the high state of elaboration to which this manufacture has now attained. In those for dining and drawing rooms a novel feature is presented, called an "Italian Pilaster, which is so printed in flock as to become in relievo, upon which two golds are applied, thus producing a raised ornamental design not hitherto executed in paper staining, capable of being applied to stars or set figures generally over the walls, and with excellent effect. On another panel is shown a new process of printing, and of repeating the printing of one flock upon another; this is capable of producing a very high relief. It is first hung upon the wall, and then painted of any desired colour, and shows no joint, exhibiting a perfect and beautiful relievo pattern. The price commences at 8*d.* per yard." A very handsome lectern (400) stands in the principal room. The name of the designer is not mentioned, but it is altogether a superior production. It is considerably enriched by colour.

Mr. Norman Shaw's Bookcase and Writing Table (212), executed in oak, and inlaid with different kinds of woods, by Mr. Forsyth, is a clever Mediæval conceit. It is large, and minutely finished in every part, abounding in arcades, shafts, zigzags, crestings, and other orthodox features; but why the upper stage should be made to lean forward appears inexplicable; the anomaly being the more glaring inasmuch as it seems contrary to the principle of shafted arcades that they should be otherwise than vertical. The hinges and locks manufactured by Mr. Leaver, of Maidenhead, are among the most satisfactory parts of the design.

The uses of Davis's Patent Marmolite are shown practically in several specimens in (214), also generally in a perspective drawing in the first room of the Exhibition (71). In the first of these we have silvered glass, with letters in gold and colour, and painted figures, executed by Mr. Horner, which is well calculated to display the quality of the invention, which is stated to "protect absolutely the silvered glass and painted design from all atmospheric influence—heat, cold, or damp, and rendering it indestructible except by extreme force. This protection, combining as it does mechanical with chemical agencies, removes one of the greatest obstacles hitherto presented to the extension of decorative art for ornamental and useful purposes, more especially in the open air, or in superheated chambers, such as theatres, concert-rooms, &c." There are also various specimens of Imitated Marbles, of Stencilling "Marmolited," and of plain Marmolited surfaces for walls, &c. On the whole the invention seems likely to be a serviceable one, but as regards this, and many other of the "materials" around, no information whatever is given on the subject of prices. This is a great mistake, and must surely arise from inadvertence on the part of the several proprietors, but time is left yet for them in some degree to remedy the omission.

THE ARCHITECTURAL EXHIBITION.

(Concluded from page 126.)

Resuming our notice of this exhibition, we shall first mention a sheet of "Old Architectural Drawings" (140), similar to some that appeared from the same source on a former year. They include two sketches in Caen by the celebrated J. S. Cotman, also a "Design for a ceiling," by Sir James Thornhill. In all of these the interest centres quite as much in the artists themselves as on the subjects they have pencilled. (141) and (165) inasmuch as they are companion pictures, illustrating one another, should of course have been placed near enough to be examined together, instead of, as now, quite apart. Each frame contains several carefully-drawn and tinted perspectives of "Buildings recently erected on the Spring Grove Estate, Middlesex, W.," by Mr. T. Page, consisting almost exclusively of detached villas and the schools. While the latter are quite of the stereotyped kind, we observe that the former are treated with considerable variety in design and style, and appear uniformly of good proportions, though the smallness of the scale to which they are shown precludes detailed criticism. It may be remarked, however, that the prevailing materials as indicated are red brick, with stone dressings. The key-plans which are added appear well arranged.

Mr. R. J. Withers is, as usual, an abundant contributor. In (144) we have six anastatic views of simple village churches, designed or restored by that gentleman. In these there is nothing to call for special remark, unless it be in commendation of the novelty of treatment displayed in the west end of the "New Quay Church, Cardiganshire," as proposed to be rebuilt, and in which the two massive buttresses which support the bell turret (square at the base, and octagonal above) are ingeniously interwoven with the lighter screen which forms an extended shelter to the entrances: the grouping of the whole is exceedingly good.

We now approach (145) one of the very few schemes for polychromatic decoration which the exhibition presents. It is ecclesiastical, and executed by Messrs. Clayton and Bell, in the "Tympanum over chancel arch, Salterhebble Church, Yorkshire." The subject is the Ascension, the principal figure occupying the centre, above the apex of the arch, and inclosed in a vesica, while, lower down, are ranged the apostles, six on each side, whose upward gaze is directed to the rising Saviour; while appropriate texts, in Latin, are interspersed on scrolls. The complexion of the whole is in sympathy with archaic precedent, the figures being severely outlined, and scanty rather than profuse in colour. Good and careful drawing is evident throughout.

In Mr. C. H. Cooke's "Design submitted in competition for new Almshouses, Faversham" (160), we regret to observe that an *ad captandum* style (which may be considered all but synonymous with *competition*) appears to have betrayed him into sacrificing the common-sense simplicity which should pervade this class of building, for the sake of getting a so-called effect by perpetually irregular forms and broken outlines. This is especially reprehensible in a long-stretched frontage like that before us, for these uniformly-recurring small breaks on plan, instead of insuring variety and picturesqueness, as was probably the author's aim, are in reality but a species of monotony, and that of the most meagre kind. We must also take exception, too, to the crocketting of the spirelet to the chapel staircase, which would have been better omitted, as also that to the lead (?) spires near the two wings. The chapel is placed exactly in the centre of the front, the walling material being Kentish rag, while the prevailing material of the rest is red brick; this change of colour is a great gain to the design in point of effect, and it would have been still more serviceable had this centre portion been brought forward so as to detach itself more palpably from the general frontage. In Mr. C. N. Beazley's competition design for the "Darlington Markets" (146), the principal study seems to have been the effective use of cheap materials, mainly yellow, red, and black bricks. The window jambs are of stone, except to the markets, which are of wood, and the brick walls would show in the interior throughout, except in the Board's offices. There is an open-timbered roof to the assembly room.

While cordially approving of the endeavours now put forth to render various coloured materials more serviceable in our modern buildings, especially in the way of construction, we are not sure whether the introduction of expensive marbles for such homely purposes as the drinking fountains in our streets, is not venturing a little too far. Good-looking and durable they should unquestionably be, nor is this incompatible with a certain amount of elegance, giving them at least an air of consistency; but in the present rage for these desirable adjuncts to our highways and byways there is a danger of overstepping the proprieties of the case, even with the most laudable motives. In expressing this conviction we could illustrate our meaning, if necessary, by reference to several recently-erected structures of the kind, and to others now in preparation, such for instance as that shown in (148), to be erected from the designs of Mr. Cæsar Long, at the Railway Terminus, Shoreditch. In general idea it bears the Classic stamp, consisting of four piers, carrying semicircular arches surmounted by a frieze and cornice, the whole standing on a deep plinth sloping to the ground. The latter is to be of blue granite, the piers of red, and the facia of the frieze is to be inlaid with green and other coloured marbles.

In Mr. H. E. Cooper's "Design for Wedgewood Institute submitted in the second limited competition" (156), we recognise a closer following of Palladian rules than is usual in modern buildings: and the same may be said of Messrs. Green and De Ville's "Hartley Institution, near Southampton" (224), which is a particularly well composed design, in which the subservient parts are contrived so as to combine well with the more important features. We are glad to be enabled to compare this—the selected design—with several others which entered the lists in the same competition, and to be able to confirm, so far as the means are afforded us of judging, the wisdom of the decision. The next best design for this building which is here shown is (202) by Mr. R. W. Edis. This, though by no means an equally successful production, has the characteristic of being of the Domestic Gothic style throughout, as opposed to those ecclesiastical details which would appear from their general introduction into every class of work to be all but unavoidable. Two other designs for the same institution (175, 259) may be passed over without comment, save that they are decidedly inferior to those just referred to, while all four offer a curious illustration of the diversity of schemes which the same subject will create in different minds.

"The Chapel, St. Patrick's Cemetery, Leyton, Essex" (163), by Messrs. Willson and Nicholl, is shown in an interior view only. Architecturally speaking there is not in this much to notice, but poverty in this respect is amply atoned for by the aid of polychromy, which is agreeably interspersed, among the wall surfaces especially. The roof consists merely of polygonal rafters, shown in the drawing of far too slender scantling to produce a good effect, however they might serve their purpose practically. The "New Corn Exchange," and "New Corn Hall, Norwich," both by Messrs. T. D. Barry, Goodwin, and Butcher, are exhibited in (168, 169). The interior of the former has an imposing appearance, but errs in proportion, owing to its undue loftiness. There are two rows of iron columns dividing the area into three spans, the principal one being semicircular. Semicircular arches, also of metal, spring transversely from these columns, and their spandrels are pierced with well-designed scroll-work in the same material. The pervading style may be termed the Byzantine.

Mr. E. B. Lamb sends several works, all stamped with that peculiar originality for which he is distinguished. Among these (172) most approves itself to our taste; it is indeed a genuine specimen of Tudor work, exemplified in the "Restorations and additions to Melbury," the Earl of Ilchester's seat, near Dorchester. We notice on the flank side what seems to be merely a whim of the designer—viz. that an entrance door, and some successive small windows above, are placed exactly in the retiring angle of the building, half of each being in one wall, and the other half, at right angles, in the abutting wall. On constructive principles this is objectionable; nor do we quite like the kind of crocketing which is carried up the coping of the several gables. The "Church of the Holy Trinity, Knightsbridge," by Mr. R. Brandon, is well elucidated by the exterior (176) and interior (182) views, so elaborately drawn and coloured. The difficulties which had to be contended with in transforming a most unsightly pile of building into the present more than sightly form, are only so many proofs of what ingenuity and good taste can accomplish. For the interior a large amount of light is obtained in a particularly novel way—namely, by a veritable clear-story, constructed in the rake of the roof itself, and extending on both sides to the full length of the church. Some such expedient was rendered necessary owing to the building being completely hemmed in among houses, except on the street side. By this mode of treatment, the roof, though it would produce externally, if seen, an anomalous effect, assumes within (from its intersecting timbers, and the play of outline caused by the curved braces traversing in all directions) an agreeably busy air. The construction of this is seen more clearly in a large-scale model of two or three bays, which finds a place on one of the tables in the room.

From the practical we again turn to the picturesque, our eye being arrested by the two beautiful architectural groups which Mr. C. L. Eastlake has so successfully transferred to paper in (177) and (189), the former being the "Courtyard on the north side of Rouen Cathedral," and the latter "Sketch at the foot of the Tour de Saint Romain, Rouen Cathedral." Of these, suffice it here to say that the subjects are worthy of the artist, and the artist equal to the requirements of the subjects. Mr. R. Brandon, in the "North-east view of Datchet Church" (179), has again engrafted not a few continental details, aiming perchance to gain thereby an additional picturesqueness. This has been, in outline at any rate, achieved, but at the expense of that English-looking character which our churches should in the main unquestionably preserve, whatever hints we borrow from those of other countries.

Mr. J. L. Pearson's "Church proposed to be built in London" (183) is a worthy exemplification of what we are endeavouring to urge: a large building evidently, and grasped by a masterly hand. The view here given is a north-west exterior, displaying to great advantage the bold composition of the west end, with its deeply-receding and gabled entrance, its massive buttresses and flanking towers; also in the distance (rising nobly at the eastern extremity of the aisle, and attached to it only by its south wall) the lofty tower and spire, which in every part of its composition is a perfect study. We may add parenthetically, that a second exterior view, as well as an interior of the same church, are exhibited in the present Architectural Room at the Royal Academy.

The most telling in effect of Mr. Street's contributions is (185), a bird's-eye view of "All Saints' Church, Parsonage-house, and Schools, in course of erection at Denstone, Staffordshire." The chief peculiarity noticeable is that the roof of the chancel is made altogether higher than that of the church, and that the bell-turret which is attached to the end of the north aisle has a conical termination, and is apparently circular to its base: the apse is octagonal. In the four angles of the picture-frame are small vignette sketches, cleverly touched in, and which explain certain special portions of the design. The whole are etched, as usual, in pen and ink. A satisfactory design for a "Villa at Highgate," by Mr. C. Gray, to some of whose former works of this kind we have before alluded, forms the subject of (191): it is Italian in character, and built of red brick, relieved judiciously by bandings of a different colour. In the "Interior Views of the large Coffee Room and Entrance Hall of the West Midland Hotel, now being erected at Great Malvern for the Great Malvern Hotel Company," by Mr. E. W. Elmslie (192), we have two small drawings which promise well for their originals, so far as means are afforded for judging. Both the apartments are evidently spacious, and furnished throughout in the Gothic style, with details of a suitable kind: we especially note the interiors of the windows, and the wall surfaces, which are less commonplace than the design of the ceilings.

(196) The "New Wing at Nun Appleton, near Tadcaster, now erecting for Sir Wm. Milner, Bt.," presents the same versatility which is manifested in all Mr. Lamb's designs: it here is evidenced chiefly in the multitudinous series of brick corbels, which are most persistently applied over the whole frontage. Cleverly managed they undoubtedly are, but we question the desirableness of introducing so many, even where they are intended to form, as here, the salient feature of a design. The chimneys also appear overdone in other respects. The "Cricket Pavilion erected for Tunbridge School, Kent," by Messrs. Wadmore and Baker (198), has the recommendation of being well suited to its purpose. It consists of a long brick building, with a projecting open covered way all along the front, with a second story of the same kind in the centre, which is gabled back into the main roof. These portions are constructed in wood, and while they supply a convenient shelter for the visitors, the depth of shadow which their well-proportioned outlines create adds considerably to the vigour of the design, and fully compensates for the absence of more ornamental, but in this case unnecessary, features.

(203) "Trinity Church, Shanghai, China," by Messrs. Stevens and Robinson, has been so far adapted to the peculiarities of the Eastern climate as to have its brick walls coated with the coloured cement of the country, while ironwork is used in the construction of the roofs, owing to the quick decay of wood when so exposed. In its design there is consequently a somewhat strange aspect, the tower having a completely English ecclesiastical look, while the rest, from the pitch of its roofs, projecting eaves, barge-boards, and other features, partakes more of a domestic character. We venture to suggest whether, with all these precautions to secure coolness of temperature, the windows are not both over numerous and needlessly exposed.

On the end wall of this room are several competition drawings submitted for the New Church at Torquay, by Mr. C. Buckeridge, but not mentioned in the catalogue. They are in the Early style of Gothic, and, both in respect to design and drawing, equal to most around. There is no steeple, but a small circular bell-turret rises prettily at the east end of the north aisle, grouping admirably with the surrounding parts, and is the leading feature of the exterior. Internally, the seats and roof are open, the latter having cambered tie-beams to the principals, with a king-post shaft, from which spring carved brackets in all four directions, the general form of the roof being polygonal. In (220) we have another design for this church, which is by Mr. Appleton, and much less satisfactory than the one just described. The selected design (we may mention) is exhibited at the Royal Academy.

The two competition drawings, by Mr. Joseph James, for the Congregational Church, Lower Clapton, appear in (218, 222), and are much above the average. Though there is no plan attached, the outlines seem to show that the architect has repeated the arrangement which he has carried out in a similar edifice at Barnsley, including the peculiar design of the transepts, and in the triple windows of the west end. From the unusual height it may be inferred that galleries are provided for. The best portion, we think, is the tower and spire, which, in the belfry stage particularly, is very skilfully managed. We allude more especially to the battering of its four walls from the springing of the windows upwards, by which means an effective gable is gained as a hood to the principal windows.

The best arrangement of hospitals is a subject still under discussion, and in (225) Mr. C. Hawkins exhibits a "Design" which has been evidently well studied. The plan is of the H form, and consists of three stories, besides a basement, the centre part being allotted to the board-room and the apartments of the physician, secretary, &c. There is accommodation for 250 patients in 10 wards, each 100 feet by 24 feet and 15 feet high, and containing 25 beds. There are also two day-wards for convalescent patients each 45 feet by 18 feet. Open fireplaces are proposed throughout, while, to insure as thorough a ventilation as possible, the wards have windows on either side carried up to near the ceiling. The design of the elevations would admit of considerable improvement.

The "Original Sketch for the Interior of St. Peter's Church, Westminster" (229), by Mr. R. Brandon, may be pronounced one of his most successful efforts. In producing this result the aid of colour has been called in, not lavishly, but in due subservience (as we think it should always be) to the constructive elements of the building. The roof is particularly handsome, the idea being borrowed, if we mistake not, from that of one of our most beautiful Norfolk churches. For a simple village church, that now being built by Mr. G. E. Street at Wymering, of which an exterior view is given in (230), presents an excellent model. It consists merely of nave, chancel, and south porch, with a square shingled bell-turret at the west end. In a clever pencil drawing (236) Mr. Norton shows his design for the "Proposed College at Clifton," which, though possessing some good points, is as a whole inferior to many previous ones from the same hand. There is throughout an unfortunate spikiness (caused by the everlasting repetition of gable and pinnacle) which is detrimental to the proper balance of the several parts. For the want of a plan being given, we are unable to refer to the arrangements, but in (232) is shown a perspective view of the school-room.

Mr. Burges' two drawings (233, 238) are in pen-and-ink, and marked by his peculiar eccentricities. The former, termed a "View of a Mediæval Town," is a close imitation of the old style of wood-engraving, for which, indeed, it might readily be mistaken. The latter shows the water-closets erected by him at Gayhurst,—a circular building, with radiating divisions, and having a conical roof terminated by a ventilator masked by the figure of a Cerberus. "Farnham Church, Essex," as restored by Mr. J. Clarke, is shown in three drawings (235, 249, 263), which seem wilfully separated. Some of the building, it is stated, is so dilapidated as to be "beyond restoration," and the architect has not adhered by any means to the former work in his present one; nor can we congratulate him on offering any better exchange. Though the old building was partly in a late style, it was picturesque, and not devoid of character, in both which particulars the new edifice is wanting.

(243) Is a frame comprising several subjects, by Mr. G. Truefitt, and they comprise "A House in course of erection at Muswell-hill," "Gravestones," and "Houses erected and in course of erection on the Batson Estate, Holloway, from his designs and under his superintendence." In all these is perceptible that ability which infuses good taste into simplest matters, and Mr. Truefitt's skill in the treatment of materials, brick and ironwork especially, is well known. The sketches before us are but slight, yet sufficiently indicate what we mean. (250) The "Cabinet Manufactory and Show Rooms, Liverpool, erected for S. Abbott, Esq., from the designs of Henry Sumner," have already appeared as an illustration in our Journal of March 1859.

Several highly finished and artistic views of Mr. Goldie's Roman Catholic church at Lanark, have been made by Mr. H. W. Brewer, and as exhibited in (252) form by far the most showy drawings in the galleries, being well arranged, and inclosed in an appropriate hinged frame, enriched with suitable carving. There are in all seven views, of which that of the Bapistery is altogether the best. In this part more especially is there an elegance of proportion which in all respects pleases the eye, while the elaborate yet chastely-designed font-cover leaves nothing to be desired. Daylesford Church, Worcestershire, by Mr. J. L. Pearson, is prettily rendered in several drawings, some in this exhibition, and others in that of the Royal Academy. Thus (253) gives the north-west view, and shows a cruciform church with a low tower crowned by a square spire, not much higher than an equilateral triangle, its large gabled lucarnes constituting the most striking features. But in other respects there is in this design a great exception to the ordinary style of modern work, it being by no means a copy from ancient precedents, nor yet an utter ignoring of their legitimate influence; thus novelty is associated with experience, the result being harmonious and consistent throughout. Totally in contrast with this we must mention (257) "The Parish Church, Warrington, Lancashire, as rebuilt A.D. 1860," by Messrs. F. and H. Francis, which is in that ultra-modern style now happily almost exploded. The plan is cruciform, and from the central tower rises a most attenuated spire. Professing to be Gothic, its authors have moreover selected an inferior age—the Flowing Decorated—whence to glean ideas, and it is matter of regret the opportunity for erecting a more worthy structure has been lost.

In (264) Mr. Goldie has another collection of sketches of works in progress—porches, monuments, drinking fountains, &c. No. 3 of these, the "Porch of St. Pancras Church, Ipswich," has unquestionable novelty, the entrance doorway being fancifully designed, while, by way of finial to the main gable, a full length statue (of the saint, we presume) is introduced, sheltered under an overwhelmingly heavy canopy. Two views of the "Malvern Link Hotel," by Mr. Elmslie, form the subjects of (272, 273). We have in the earlier part of our notice (73), referred to a similar building by the same architect, for Great Malvern. The same ideas here prevail again, but they are perhaps better handled; the Gothic details are apparently more consistent throughout, and the red brickwork, being well toned with black, imparts a sufficient variety of colour, while a long half-timbered bridge over the high road, but for the purposes of the hotel, enlivens the whole with a great amount of picturesqueness.

Considered as architectural drawings, in the true sense of the word, there are few in this exhibition that can take rank with those of the "Morning Chapel of St. Paul's Cathedral," five in number (267—271), and which obtained the silver medal at the Royal Academy in December last. They have been prepared from actual admeasurements (as stipulated by the conditions of the reward) by Mr. T. H. Watson, and consist of plans, sections, elevations, and parts at large, all carefully outlined, and slightly washed in with Indian ink. Such analyses as these, applied to the best examples, are among the most instructive means of advancement that can be suggested to the architectural student, independently of the honourable distinction which awaits his patient and well directed labours. "Hodnet Hall, Market Drayton," as about to be altered by Mr. E. B. Lamb (282), is a half-timbered mansion, worked out in the true spirit of that kind of construction.

The advertised competition for a Clock Tower to be erected in the High Town, Hereford, aroused a spirited contest, and no less than eleven of the designs are brought under our notice here, which moreover, by some piece of good fortune, are all placed together. The selected design is not among these, but out of those before us we should distinguish, as the best designed and most appropriate, those by Mr. F. Rogers (300), and Mr. C. H. Mileham (306). The first is a well-proportioned Gothic campanile, showing very good treatment in its different stages; the upper one is gabled through lengthwise, and has two smaller gables on each of the sides. It would have been better had the walls tapered more. The second is of less obtrusive character, and forms part of the continuation of the street, being gabled, and rising but a trifle above the adjoining houses. It is of red brick, banded. The clock is in this design shown projecting from the tower, over the pavement.

Upon the first screen are two or three specimens of an entirely new system of decoration by means of "Appliqué Needlework," and suitable for ecclesiastical and other architectural purposes. The exhibitors are, in (316, 317, 318), Lady Mildred Hope; and, in (323, 324), Mr. Alfred Bell. The three first-mentioned comprise a complete specimen, a half-completed ditto, and a cartoon. "This method of needlework was invented for and applied to the new choir hangings in Cologne Cathedral, designed by M. Ramboux, and executed by 300 ladies of Cologne, under the direction of Mlle. Martens. These specimens have been prepared by Mlle. Martens in order to exhibit the process of working in various stages." To give a general idea of the mode, it may be described as a kind of patchwork in different colours, reminding one of stained-glass; the minutiæ, such as features, drapery, &c., being filled in by subsequent stitchings in different silks, as required. (323) Is an unfinished portion of a "Banner or Standard Screen," and (324) a portion of a "Piano Front," consisting of three larger compartments, containing respectively the figures of Jubal, David, and St. Cecilia, and two intermediate and two end compartments, narrower, and containing figures of a nightingale, blackbird, canary, and lark, all worked in silk embroidery.

In designs for church furniture, Mr. E. Sedding invariably excels, and it is a branch of art to which he has almost specially devoted himself. We therefore welcome his beautiful drawings as shown in (321, 326, and 330). There is a degree of quaint originality infused, which is congenial with their purposes, and all are more or less improved by the enamelling and other coloured effects which are tastefully interspersed. Mr. C. H. Mileham's "Competition Design for a Church near Ramsey, Isle of Man" (332), is a very creditable one, if we except the poverty of the nave and aisles. The transepts and semicircular apses at the east end are skilfully planned, and combine most satisfactorily with the central tower, which is, with its spire, of low proportions. The style is Early Pointed.

Mr. Colson's "National Schools and Teacher's Residence, Farnham, Surrey" (340), in execution look better even than in the drawing. They are built of local stone, with Box ground stone dressings, at an expense of £2000. The warehouse erected a year or two since for Messrs. Sykes in Wellington-street, Leeds, by Mr. Corson, is scarcely up to his usual standard, if it may be judged by the photograph in (357). It appears to be a kind of Gothicised Italian work, principally notable for its entrance doorway, which is cleverly managed. The shafts to this entrance are in Peterhead granite. The ordinary walling materials, brick with stone dressings. (394) shows a "Bank at Carlisle," as erected by the same architect last year. In a very fine drawing (381) Messrs. Clayton and Bell submit a "Sketch of the East Window, Louth Church, Lincolnshire, now in course of execution," which consists of two rows of subjects extending across each of the seven lights. Of the late competition for Grimsby Town-hall we observe but one reminder—viz. (386), by Mr. J. A. Davies, neither of the selected designs appearing to enable us to form an opinion as to their comparative merits. The view before us shows a very tolerable building in what has been termed the "Victorian" style of brickwork, and it is further elucidated by two plans. A number of "Selections from the Illustrations for the 'Dictionary of Architecture' issued by the Architectural Publication Society," are contributed, as usual, by its hon.-secs., in (393). The subjects are all interesting, and have been ably lithographed by Mr. Bedford. We are glad to know that this society is showing signs of revived life. The last series of drawings to which we can refer is (387—390) a "Design for a House for four brothers, amateurs of literature and art, sent in for competition to the Ecole des Beaux Arts, Paris, and for which first honourable mention was awarded to Mr. R. Phené Spiers." This is, in every sense of the word, a Classic production, evincing throughout a very refined taste. As specimens of effective colouring, too—aërial, yet sufficiently defined—they are unsurpassed by any in the exhibition, and may be consulted with advantage by certain artists whose practice would seem to denote their belief in heavy body-colours as the most reliable means of securing a telling effect.

The exhibition will close on the 30th instant.

THE PRESIDENCY OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

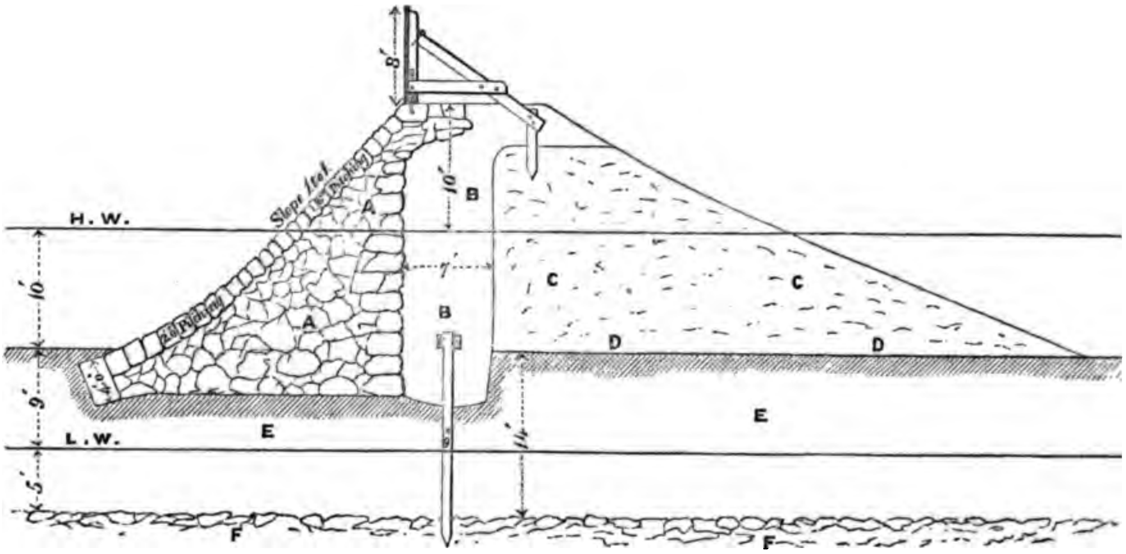
At an adjourned meeting of the Institute, held on the 6th of May, Mr. Tite, whose name has for many years been well known to our readers, was elected President for the ensuing year by a majority of the votes of the Fellows present. A second candidate had been proposed in the person of Mr. Beresford Hope, and the election had given rise to a good deal of division—or perhaps it may be more correct to say, has given expression to an existing division of feeling among the architects of the present day; the members of the Gothic school having supported Mr. Beresford Hope, and the followers of an older manner, Mr. Tite. The result shows that the parties are pretty evenly balanced, even among the Fellows of the Institute, a body which includes nearly all those senior members of the profession who are of note, while it does not include some of the younger men, among whom the great strength of the Mediævalists lies.

It is always preferable that elections of this nature should if possible be settled unanimously; but, failing that, we are glad that in having to record a contest we are also able to add that its origin was not to be traced to personal considerations. These no doubt had their weight, and the desire to have a practising architect for President had its weight also; but we believe that the larger share of the contest was caused by the motives we have referred to.

Mr. Tite, though not bringing to the presidential chair the learning, the skill, the artistic taste, and the graceful courtesy of the accomplished and venerable Cockerell, who has vacated it, has nevertheless been a distinguished architect; and as a man of experience, and well practised in public matters, he will, there is no doubt, prove a very suitable President, and we are glad to chronicle his election. We should however have preferred to be able to record a choice under circumstances of perfect unanimity, and such as would have more thoroughly favoured what is no doubt one of the greatest movements of the artistic world at the present day.

THE RECLAMATION EMBANKMENT FOR THE NEW DRY DOCK AT LEITH.*

By George Robertson, C.E., F.R.S.E.



Scale, 16 feet to 1 inch.

AA. Rubble deposit.
BB. Puddle.
CC. Sand filling.
DD. Original surface of shore.
EE. Sand.
FF. Clay with boulders on the surface.

The question of gaining ground for dock purposes from the East Sands of Leith is by no means new—the wonder is that it has not been done before. So long ago as 1799, when Rennie was consulted as to the position of the proposed wet docks, he took into consideration the advisability of making use of the east side of the harbour for that purpose. He gave in designs for at least one dock of 6¾ acres, with 18 feet of water, to be constructed on land reclaimed from the East Sands by a sea-wall parallel to the shore. As this was to form a cofferdam during the construction of the works, he considered it would be necessary to carry it through the deep sand down to the natural clay. The clay level on this side of the harbour being below the level of low-water, this could only be done by laying the foundations within cofferdams, and pumping out the water by a steam engine. The cost of this reclaiming wall Rennie estimated at £35,000, of which £14,000 was for dams, &c. alone, with the candid but unpleasant proviso that the item was very uncertain. From my experience of the situation, and the running nature of the sand, I believe that sum would have proved totally inadequate. The higher and more favourable level of the clay on the west side of the harbour settled the question against the East Sands; and the old wet docks were built by Mr. Rennie in the beginning of the present century.

In 1828 the east side had another chance of being made useful, for Telford suggested that a rubble wall might be advantageously thrown out from the back of the old pier, and the land within reclaimed by depositing behind the wall the mud obtained from dredging the old harbour.

In 1848, when the Victoria Dock was required to accommodate the increasing number and size of vessels, the situation of the existing docks weighed too heavily in favour of the west side, which again gained the day.

When it was proposed some years ago to build a large graving dock, Mr. Rendel prepared a set of plans in 1854 for a dry dock entering from the west side of the Victoria Dock. However, the limited amount of quayage in that dock made the interference with a berth 300 feet long so serious, that Mr. Rendel transferred his plans to the East Sands. The sanction of the Treasury was obtained in 1858, and the works commenced accordingly.

The dry dock is somewhat peculiarly situated, the site being almost an island, with a circumference of half a mile, of which only one-eighth is dry land. The harbour side, where the depth of water is 24 feet, is protected by the old stone pier, built at the end of Queen Anne's reign: eventually this pier will be removed to form the entrance to the new dock. The south side is threatened by the water in the timber pond; but as the depth here is not great, and the distance from the dock considerable, nothing has been done to guard this side. The real danger was on the north and east sides, especially as it was desirable for several reasons to build the dock as near the embankment as possible. The level of the natural clay over the whole area may be taken as 24 feet below high-water of spring tides—the same level as the cill of the caisson invert. The thickness of the overlying bed of sand is 14 feet under the bank, and 24 feet at the old bulwark, the excavation being on the average through 18 feet of sand. The depth of water along the bank is 10 feet only, but with a north-east wind the waves roll in over the long expanse of flat sands with great velocity, and with a force very destructive to all unfinished or insufficient work.

The embankment has to do the double duty of reclaiming the sands, and of excluding the water from the excavation within, the lowest point of which is 33 feet below high-water. The back of the dock wall is 90 feet from the coping of the bank,—as near as it was possible to put it, allowing for the necessary slopes and benches. The success of the bank in excluding the tide depended on the truth of the principle—that water in traversing a certain distance of sand encounters so much friction that the initial pressure is at last destroyed, and the water throttled to such an extent as to be within easy control of pumps. That, in short, within limits a sufficiently watertight cofferdam can be formed of sand itself. The correctness of the principle has been satisfactorily proved by the very small quantity of water which now comes through under the bank into the cutting. The leakage along the whole 1400 feet of cofferdam can be kept down by a 9-inch chain pump, working at most one hour in four; and a great deal of even this quantity comes from the harbour side of the works.

---

* Abstract of a paper read before the Royal Scottish Society of Arts.

The bank is formed of three essential component parts,—a watertight core of clay in the heart of the work, continued to the natural clay, where the dock approaches nearest the bank, by a row of 9-inch sheeting piles; on the sea-side of this a protecting wall of dry rubble faced with pitching, and on the land-side a backing of common sand from the shore. The puddle-wall was made 7 feet thick, at considerable expense, in order to obtain great weight and breadth on the sands below, to cut off the water as much as possible, and to diminish any risk from the cracks caused by settlement or imperfect puddling. Any leakage through the clay would have washed down the sand backing, and caused the total failure of the dam. For a length of 580 feet, from the caisson groove to the head of the dock, a row of 9-inch sheeting piles, 18 feet long, has been driven down to the clay, both to assist the watertightness of the bank and to steady the foundations in case of a great run of water through the sand. These piles were driven by means of a small steam-engine, which ran along the stage erected for depositing the rubble of the northern half of the bank, and drew up two rams at once. The north and east halves of the bank were each commenced at the shore end, and were arranged to meet at the north-west angle, where the sands are lowest; so that all the water in the inclosed area might drain off with the falling tide before the banks were shut. The greater part of the north bank was built from a staging, with whinstone rubble, which came by sea from Queensferry; the east bank from an end tip, with Craigmillar sandstone, brought on the works by the North British Railway. The deposit in the former was faced as the work proceeded upward: in the latter it was built into a rough wall and faced after the bank was closed; this was done for the sake of expedition, but considerable risk was run in leaving the east bank unfaced for a length of time.

The general routine of work consisted in first getting in a length of toe-stones, say 40 feet, then excavating the sand behind them, and depositing the rubble before the tide came in and filled the trench again with sand. The rubble was brought up some height, then the puddle put in, and last of all the filling behind. Each component part had to be pushed on a length in turn—the rubble would not stand without the clay behind it, and the clay would not stand without the sand backing. Whenever a rough sea came, the unprotected length of each suffered, and was knocked over; but the sand filling suffered most, for the least swell pulled it out to a long slope, which required feeding to keep it above high-water level. When the opening between the two banks grew so narrow that the ebbing-tide began to plough up a channel in the sands half a mile long, it became a question whether it would be easy to shut the bank in one tide: in case it was found desirable not to attempt it, a timber shoot several feet in area, was built into the deposit, to be continued if wanted through the puddle and backing. By means of a shuttle in this, the inclosed tide might then be run off at succeeding low waters. It was very desirable if possible not to make use of this, for there is great trouble in keeping watertight any communication through a wall of puddle. I had plenty of experience of this when engaged on the late extension of the London Docks, where the leakage along the very bolts through the regular timber cofferdams, caused more expense and trouble than the Leith bank has yet occasioned, though longer, built of dry rubble, and upon deep quicksand.

The bank was closed without much difficulty, in one tide, on the 25th May, 1860; but before the work could be faced and rendered secure, a heavy swell from the north-east broke over and filled the inclosed area; an opening had therefore to be made, which was again closed on the 9th of June. After the exclusion of the tide, all the water with which the shore and bank was saturated drained down to the lowest level, making rather a formidable pond of some two acres in extent. This had to be got rid of before any excavation could be taken out, or the pumping-well sunk: it was taken over the top of the bank by a double syphon of 2-inch lead-pipe, which in a few days quietly and inexpensively drained the pond, without the neccessity of putting up pumps for that purpose alone. The whole reclaimed area of nearly 6 acres then became hard and dry, as if the tide had never rolled over it, and the excavation has been since taken out to its full depth. In a similar manner the sea might be excluded from any extent of the 500 acres of the East Sands which may become necessary for dock or other purposes. A strong timber parapet fence has been put up, and bolted on to the coping of the bank, to throw off the heavy spray of the sea; at some future time, when all settlement is over, this may be replaced by a masonry wall.

The bank does not form a separate contract with Mr. Wilson, the contractor for the dock, but I have made it the subject of a separate notice, because it stands practically alone, having to be completed before the dock could be commenced. Mr. A. M. Rendel is the engineer-in-chief to the Commissioners for the Harbour and Docks of Leith; and the works are being carried out under my superintendence.

THE STATICS OF BRIDGES.

III.—*The Arch.*

In a preceding paper (*ante* p. 60) we inquired generally into the duty imposed upon a bridge. We found that the load impressed upon the several parts of the structure tendencies to turn in opposite directions. On proceeding to examine these tendencies to turn, or Moments of Rotation, we found their values to depend upon so simple a law, that two successive processes of mere addition would give us either the series of the moments themselves, or numbers proportionate to them; and we showed this law to be equally applicable whether the load were carried by an arch, a chain, or a girder.

These tendencies to rotate would, if not counteracted, of course lead to the failure of the bridge. Equilibrium results from the moment of rotation at every point being met by an opposite Moment of Reaction of equal amount; the tendency of the moments of reaction being to turn the several parts of the bridge upwards, so as to raise the load,—a tendency that may be seen partially taking effect when a settlement in the haunches of an arch is accompanied with a rising at the crown.

The calculation of the moments of rotation, or, as we may call them in the case of a beam, the Units of Strain, gives us therefore alike the amounts of these moments, and those of the equal moments of reaction which are essential to the stability of the bridge. We can now go a step further, and look at the various shapes in which these moments of reaction (of which as yet we know nothing more than the amounts) are found in different structures, and the several ways in which they are brought into play. In other words, we have now to examine how the general principle we have laid down operates specially in each form of bridge. In such an inquiry the Arch has a kind of prescriptive claim to the first place. It is with the arch therefore that we propose to begin.

The reaction to which the arch owes its stability results from compression. The principle has been already shown in the simple case given *ante* p. 61, Fig. 4, where a load (W) is carried by two bearers (AB and BE), which lean upwards against each other, and have their feet kept from slipping outwards. The apex (B) cannot sink without reducing the length of the bearers; and consequently the load no sooner begins to depress this apex than a compression ensues, which brings a force of reaction into play. As the deflection increases the reaction gathers strength, until at length the settlement reaches a point at which reaction balances action, and further deflection is arrested.

Let us now see what are the conditions of the equilibrium that has thus prevailed, and what are the consequent compressions in the bearers. In the right-angled triangle shown in the figure already referred to, EB represents in direction and amount the resultant pressure on the bearer AB, and this pressure is resolved into BR vertical and ER horizontal. The vertical pressure BR can be neither more nor less in amount than the portion of the load W which the bearer AB carries: the horizontal pressure ER is the thrust of the arch, and evidently results from the inclined position of the bearer. The less the rise of AB, the less will be the angle E, and the greater will be the thrust represented by ER.

Equilibrium (which we are supposing to exist) requires that the opposite horizontal thrusts on AB and BE at the point B of compressible materials, and bound together by cement at the joints.

We have seen that actually the reaction that gives the thrust is brought out by the compression of the material, and that the unequal way in which this compression acts upon the voussoirs causes a bending and consequent spreading, the degree of which governs the amount of thrust. We must now for a moment shut our eyes to this truth, and inquire how thrust would be generated in the incompressible dry arch which it is found convenient to imagine.

Take the elementary arch shown in Fig. 13. Each semi-arch has its tendency to turn, and it is the horizontal thrust which keeps it in position. But this thrust, being the reaction brought out by the effort of the semi-arch to turn, can only come into play when turning is really beginning to take effect. We must therefore consider each semi-arch as *on the point of turning*—the joints all but opening—before we can say that there is any horizontal thrust at all. Now the only fulcra upon which it is possible for either semi-arch to turn (according to our present hypothesis, which is inconsistent with the idea of a neutral axis), are the edges A, M, B, O, E, N; and the downward turning which the load induces must have for its fulcra the outer edge B at the crown, and the inner edges A, E, at the springing; the tendency being to throw the voussoirs into the position shown by the dotted lines. As the joints AM, BO, and EN, are on the point of opening, it is necessary to suppose them barely touching, with no pressure to maintain the contact of the surfaces. Thus, before thrust can be exerted against the abutments, the whole of the pressure at the crown must be concentrated at the edge B, on which the semi-arches pivot, and the whole of the pressure at the springing must come on the edges, or pivots A, E. The conclusion is inevitable that the Resultant Line of Pressure passes through the points A, B, E, thus meeting intrados at springing and extrados at crown.

The same appears on examining the case shown in Fig. 14. Each voussoir here would seek to turn on its edges: the voussoir *a* 2 on *a* and 1; 2 4 on 2 and 3; 4 *s* on 4 and *c*. But these tendencies in the intermediate joints counteract one another. The joint 1 2, for example, cannot at the same time open on its outer edge as a pivot to allow the lower voussoir to turn, and open on its inner edge to allow the upper voussoir to turn. The separate efforts of the adjacent voussoirs must therefore combine to bring a resultant pressure somewhat within the joint 1 2; and the same may be said as to the action at the joint 3 4. The only fulcra therefore about which the voussoirs are really free to turn are the extreme edges *a* and *c* of the semi-arch. It is therefore through these points that the Line of Pressure must pass—extrados at crown, intrados at springing—in order that thrust may be generated. And equilibrium will ensue if this Line of Pressure lies wholly within the voussoirs between these its points of contact with the outer and inner surfaces.

But it will sometimes happen that a Line of Pressure drawn so as to meet extrados at crown and intrados at springing, will at some intermediate points pass above or below the voussoirs, so as to come actually outside the arch. It is necessary that our rule should be made comprehensive enough to take in such cases as these. In order to this we must first of all inquire into the conditions which accompany the passing of the supposed Line of Pressure beyond the voussoirs.

Take the elementary arch of two voussoirs, shown in Fig. 13. If the load is all carried at B, the Line of Pressure (on the non-compression theory) is seen in the straight lines AB, BE, which are wholly contained within the arch, and equilibrium prevails. But if the load is distributed, the Line of Pressure becomes a curve; and if drawn through the points A, B, E, it will lie quite outside the arch for a great part of its length.

What is the meaning of this? As long as the Line of Pressure lies within the voussoir we understand it to be actually the path of the resultant pressure. But when the Line of Pressure passes outside, as at V, this cannot hold good, for the resultant pressure must lie somewhere within the arch, as, say, at X. In such a case the Line of Pressure indicates no longer where the resultant pressure *is*, but where it *ought to be*, in order to produce a moment of reaction equal to the moment of load.

Thus, in the figure, if the thrust were actually transmitted through V in the Line of Pressure there would be a moment of reaction equal to the horizontal thrust multiplied by the rise from E to V (or by V P): and this would just counteract the moment caused by the load in SN. Again, the thrust, multiplied by the remaining rise from V to B, would give a moment of reaction that would just meet the moment of the remainder of the beam SB.

But as the thrust is really transmitted through X, these conditions of equilibrium are no longer fulfilled. The rise from E to X being less than that from E to V, the actual moment of reaction created by the thrust in SN is *less* than the direct moment of the load. And the rise from X to B being greater than that from V to B, the moment of reaction created by the thrust in SB is *greater* than the direct moment of the load. So that, although the thrust produces in the entire beam EB a moment just sufficient to balance the total moment of the load resting upon it, the parts SN and SB are thrown out of balance by the moment of reaction being improperly divided at RS. Thus, if the beam were severed at RS, the joint would open and the parts would turn opposite ways. In SN the load would preponderate, and it would turn downwards; in SB the thrust would preponderate, and it would turn upwards.

If there were no joint at RS, and the beam were strong enough to resist the tendency of its parts SN and SB to turn opposite ways, without breaking, the arch would stand. But its stability would be partly due to the transverse strength exerted at RS—if indeed we have any right to speak of transverse strength at all while we ignore compression. The transverse strain at RS must be such as to supply the deficiency of the moment of reaction in SN, or abate the excess of the moment of reaction in SB. It must therefore be equal to the thrust multiplied by VX; VX being the difference between the rise from E to V and the rise from E to X.

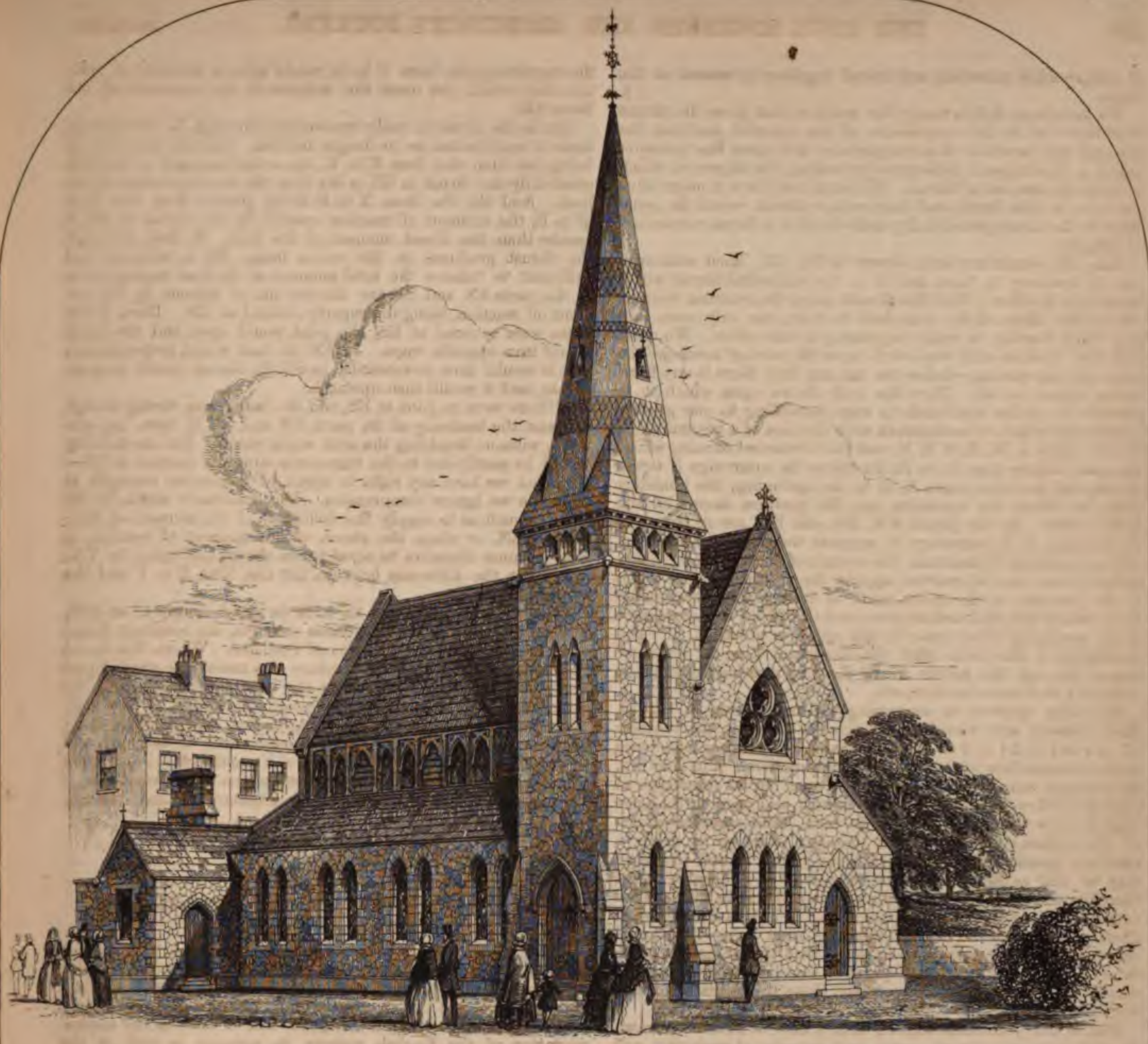
It thus appears, that for an arch to stand simply as an arch, without any exertion of transverse strength, the resultant thrust must everywhere lie in the Line of Pressure. Where this is not the case, there will be either rupture or a transverse strain equal to the vertical distance between the Line of Pressure and the actual position of the Line of Thrust, multiplied by the horizontal thrust; this product forming, in fact, the supplementary moment required to check the preponderance of the load, and to restore equilibrium. If the Line of Pressure passed below the actual Line of Thrust, the supplementary moment would be of the opposite kind, and would occasion a transverse strain tending to bend the arch upwards.

(*To be continued.*)

NEW INDEPENDENT CHAPEL AT ABERGELE.

(*With an Engraving.*)

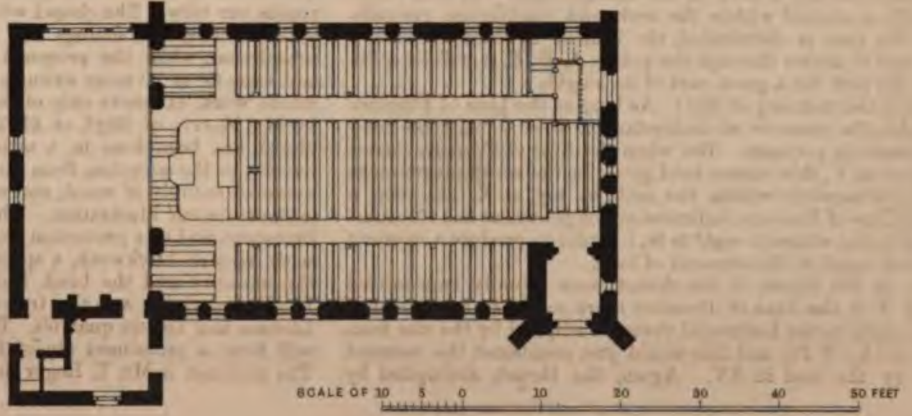
This building, of which we give an external view and a plan, is now in course of erection at Abergele, a rapidly rising watering-place on the north coast of North Wales, and situated between Rhyl and Conway, at the mouth of the picturesque vale of Clwd. The building is designed with a view to the accommodation of the English visitors in summer as well as the ordinary Welsh congregation. Accordingly a schoolroom is provided, which can be thrown into the place of worship by the removal of a movable partition, but which during the winter months will always remain separate. The chapel is 56 ft. 6 in. long by 33 ft. wide, and the schoolroom alluded to is 33 ft. long by 17 ft. wide. A vestry is also provided, and at the entrance end a shallow gallery is to be built, capable of future enlargement. The arrangement of these buildings, and the position of the entrances will be easily understood by consulting the plan which accompanies our view. The chapel will seat comfortably 350 adults, to which another 100 sittings can be added by throwing open the schoolroom, while the proposed enlargement of the gallery will add some 60 or 70 more sittings. The contract is taken for the whole work, exclusive only of heating, lighting, and fence walls, by Mr. Morris, of Rhyl, at £1633, and the work as far as completed has been done in a satisfactory manner. The principal novelty is the adoption, from motives of economy, of a clerestory executed entirely of wood, and of which the external appearance is shown in our illustration. The walls are of a fine solid local limestone, and as a protection from moisture are lined throughout with 4½-inch brickwork, a space of 2 inches being left between the masonry and the brick lining: the weather stone is from Heullan quarries, and the tracery, &c. is executed in stone from Llanasa and Telaeri quarries. The little spire is to be slated, and will form a prominent object for many miles along the coast. The architect is Mr. T. Roger Smith, of 57, Strand, London.



NEW INDEPENDENT CHAPEL, ABERGELE, NORTH WALES.

J. ROGER SMITH, ARCHT

GROUND PLAN.



J.R. Jobbins.

ON ARCHITECTURAL COMPETITIONS.

(*Continued from page* 93.)

Among the disadvantages besetting public competitions, the want of precision, system, and experience, in all those concerned in regulating the conduct of them, is no doubt one of the most grievous. The nature of the case renders it probable that the managers of the undertaking have never engaged in such a thing before, and even those who have had repeated opportunities of conducting a competition cannot always be relied upon as able, even if willing, to trace to their source inconveniences the pressure of which they have shared, or to make such arrangements as shall prevent their recurrence.

The want of perfect accuracy in framing the original instructions, and the readiness with which the framers of those instructions depart altogether from the rules they have laid down, are misfortunes which meet the competitor at the outset of his task, and do not leave him till its close. The incompetence of the tribunal before which the designs have to pass is a second circumstance that rarely fails to make itself felt—and most painfully felt: while lastly, the customary attempt at rendering the sets of plans anonymous, by prescribing that they shall be marked with a motto only, has probably opened the door for more real injustice, and certainly has occasioned more suspicion and discontent, than all the other evils put together.

The framing of conditions for a competition is a matter of so much delicacy, and requiring so much care, that even a professional man of great experience might shrink from undertaking it. The instructions to architects intending to engage in a public competition ought to comprise as precise a statement as possible of the requirements of the building, and yet ought to leave the architect quite free to select the mode that seems to him best for meeting those requirements. They ought to state the problem, but to leave the solution entirely untouched. Commonly the instructions issued fail of both these points, omitting essential portions of the requirements, and prescribing that certain methods of meeting such requirements as they do unfold shall be followed. The preliminary instructions ought to form a little code of unalterable laws. They ought to state all the conditions under which the competitor will stand, and these conditions once stated ought to be held binding alike upon competitors and judges.

That these are essential qualities for a good set of "conditions," no one can reasonably doubt, but practically to secure them would almost seem impossible. In the very part of an undertaking where the counsels of an experienced architect are most valuable—namely, the maturing the general outline and idea of an intended building—the committee or other managers usually deprive themselves altogether of such assistance; and consequently they usually fail to form any definite idea of what is wanted, and what the funds at their disposal can furnish. A much more serious evil than mere looseness in the language of instructions is here alluded to—namely, the want of foresight as to the expense of the proposed building. It is so notorious that committees in this particular allow themselves to be guided by what they wish, rather than by what they ought to expect, that many business men have grown quite indifferent to that which is really a most serious cause of regret, and look upon it as a matter of course that impossibilities should be asked by the committee, and be promised by the competitors. Practically it does not conduce to satisfactory results, if persons who are employers ask for more than they can possibly have for their money, and those who desire to become their confidential agents commence the transaction by promising more than can be done. Nothing is more really unbusinesslike, or more injurious to the moral tone of a profession that ought to stand as high as any other; and no improvement could be effected in the general regulation of competitions which would be of greater value than establishing the custom—that the requirements should be within the bounds of possibility, and that the most rigid scrutiny should be instituted into the possibility of meeting them by the designs submitted, without exceeding the originally named expense.

The next serious irregularity is the disregard of the previously framed conditions by those who have to arrive at a decision upon designs submitted. The grossest injustice is constantly committed here, and often, we are willing to believe, unconsciously committed. Very frequently the original defects of the instructions lead to their being disregarded, first by the architects, and then by the judges; sometimes the whole of them are summarily set aside, because some design, better than the others submitted, has proceeded in direct violation of them. Very often the framers of the instructions change their minds, and, being themselves judges and law-givers all in one, they scruple not to disregard what they had once established, forgetting that they are under a tacit pledge to the gentlemen who have laboured hard for them, to abide by what they had published.

Most of these defects grow out of the same cause,—the want of an intimate acquaintance with the business in hand; they are too often aggravated by a want of inflexible honesty of purpose. The assistance of a professional man whose skill and integrity were beyond dispute, would always diminish, if not remove these causes of complaint.

Professional assistance is however more needed, non-professional incompetence is more shown, in the actual examination and selection of the plans, than in any other point whatever. It is no easy thing to understand the geometrical drawings for a building. Even architects sometimes fail to see at a glance the excellences and defects of a plan submitted to them; and if "reading" a plan be a matter requiring that even those who spend their lives making plans should devote time and care to it, how much more will persons not familiar with the nature of such documents need to give it their best attention? It seems however clear, that frequently non-professional judges take it for granted that any arrangement proposed for their adoption will do, and confine their scrutiny to the external appearance of the building. Even here, however, they are still to a certain extent at sea, as they are less frequently competent to tell whether a perspective view is correct or not, than to tell whether a plan is rightly arranged.

The inexperience of any ordinary set of business men when they come to examine a set of drawings lays them open to be attracted by many circumstances that are purely adventitious, besides exaggeration or incorrectness in perspective views,—such as the scale of the plans, size of colouring, or mode of getting up in general. To prevent this, as uniform a mode of procedure as possible ought to be insisted on, both as to scale, mode of colouring, and even number of drawings. It is a source of frequent complaint that those who, having more leisure or more money than others, are able to produce very voluminous sets of plans, stand a better chance than others less favourably situated. There undoubtedly is some ground for this complaint, but it may fairly be questioned whether it will ever be possible to put competitors quite on a level in this respect, nor would it perhaps be quite just, if practicable, to adopt means for doing so. He who exerts himself the most, and elaborates his design to the fullest extent, is not unlikely really to deserve best of the judges; and though his elaborate work may be occasioned by his having ampler resources, it is by no means unfrequently the case that more zeal and greater industry are the real reasons why one set of drawings are more in number and better in finish than another.

Among other things, that breach of conditions known as "extension of time," is frequently to be deprecated, though as it is usually an open arrangement, made known to all, it is perhaps excusable. There can however be no excuse for the impropriety—constantly committed—of receiving plans after the time appointed for their coming in; a proceeding which very frequently gives an unfair advantage to the architect who has counted upon the laxity of the committee, and has overstepped the prescribed date.

When an adjudication is come to and made known, it is a matter of grave complaint that the author of the prize design is not invariably named the architect of the building. One cannot feel surprised that committees should desire to be left free to put the building into the hands of any person they please, after acquiring for a very low price the design which out of a large number strikes their fancy most. Architects however ought not to engage in competitions under circumstances which would render this possible; and public bodies would not resort to the plan quite so freely, did they know how very much of the success of a building depends on the care with which it is carried out. The money-premium is not remuneration enough to induce an architect to compete: the bare honour of gaining a competition is not worth much. It is the actual extension of practice, and the employment, honour, and emolument flowing from actually building the proposed structure, for which competitors are eager, and to which they undoubtedly are entitled. Instances have occurred in which a design only has been advertised for, with the expressed condition that the author of it was *not* to superintend it. Under these circumstances the number of competitors has always been small, and their professional standing moderate; and in the many cases where the offer of a premium is accompanied by an intimation that the committee will not consider themselves pledged to employ the successful architect, competitors always entertain the hope that if successful in obtaining the prize they shall also succeed, notwithstanding this stipulation, in procuring the employment, since, if not promised, it is yet not absolutely denied them by the terms of the conditions under which they compete.

The last topic upon which we shall touch is the custom of inviting anonymous designs, to be submitted marked with a motto only, and with precautions such as are apparently framed with a view to exclude anything like personal interest. It will be a matter for future discussion whether interest, *i.e.* personal acquaintance between the competitor and those who propose to erect the building, *ought* to be entirely excluded. It is however certain that the attempt, even if made in the most entire good faith, will be very open to failure, if the committee or other employers are themselves judges: and the underhand use of interest, or the suspicion that underhand influence has been at work, whether that suspicion be well founded or not, are so extremely undesirable, that we have no hesitation in saying that if no such middle course as will be hereafter suggested be adopted, the mottoes had better be swept away, and architects had better sign their own names to their plans; and if they go round to canvas for votes, do it openly, and allow their rivals to do so too.

Such are some of the undesirable circumstances attending upon competition. It is not pretended that architects have it in their power to remedy all of them, but it will be shown that it would be quite possible by combined action to remove entirely some evils, and to lighten the pressure of others; and it is not too much to believe that if the profession did its part manfully and well, public opinion would come to its support, and would cause the removal, or at any rate the palliation, of other just causes of complaint which it is quite beyond the power of architects to remedy either by acting singly or collectively.

(*To be continued.*)

COLOUR ON STATUES.*

By John Bell.

In March of the year before last, the subject of colouring statues was brought before the notice of this society in a paper by Prof. Westmacott. That paper went carefully over a large portion of the subject. It treated of the degree in which there were evidences of the old Greek sculptors having added colour to their statues. It also argued the subject, whether or not this was an improvement to sculpture. It also registered the professor's valuable opinion that it was not. The Dean of St. Paul's presided, and gave the weight of his learning and testimony to the view that there was no proof of the Greek statues having been coloured, except when forming parts of architecture. Prof. Donaldson and Mr. Crace however, who both took part in the discussion, inclined to the colouring of statues. Even with the chance thereby of leaving my argument incomplete, I would avoid recapitulating what passed; all which is to be found reported in the 'Journal of the Society of Arts' for March 2, 1859. In what follows indeed, I wish, as much as possible, to avoid going over the same ground, content rather to supplement than to cover the whole subject. My remarks therefore will be chiefly addressed to considering—firstly, with what object the Greeks coloured their statues when they did so, which was by no means their constant practice; and secondly, to submit the only way in which I conceive that colour can be suitably associated with statues at the present day: thirdly, with a few words as respects the joint exhibition of paintings and sculpture (as being part of the subject of colour associated with statues) these notes will conclude. In order however to attach them to Mr. Westmacott's address, I must go back a little, to make them overlap and unite, but will repeat as little as possible.

On the occasion I speak of, the Dean of St. Paul's remarked that there was a passage in Plato which was a stronghold of Mr Westmacott's antagonists, to which however the professor had not alluded. With your leave I will quote this now: it is from 'Plato de Repub.,' lib. iv., and is contained in a rejoinder of Socrates. We may remark by the way, as this gives more authority to the point of the passage, that this revered Greek philosopher was not only the son of a sculptor, but for some time himself wrought at the profession. This is the passage: Socrates speaks—"Just as if," he says, "when painting statues, a person should blame us for not placing the most beautiful colours on the most beautiful parts of the figure—inasmuch as the eyes, the most beautiful parts, are not painted purple, but black. We should answer him by saying, Clever fellow, do not suppose we are to paint eyes so beautiful that they should not appear to be eyes." This passage, we may well admit, alludes to the painting of statues—the word for statue being *andrias;* but it does not say that the flesh was painted, nor that these were marble statues which were so treated. We ourselves in our towns possess painted statues of wood, as in those of that distinguished North Briton of which we still remark images in some of our old snuff-shops. The Greeks also, as Pausanias informs us, had in their gardens and groves figures of plaster and wood which were painted. By this people however, without doubt, many statues were painted, of a much higher order than these, and even occasionally those of their gods.

Another remarkable passage from the ancient authors, brought to bear on this subject by the polychromists, is that from Pliny (lib. xxxv. cap. 2), in which he says, speaking of Nicias the encaustic painter, that Praxiteles, the great Athenian sculptor, when asked which of his marble works best satisfied him, replied—"'Those which Nicias has had under his hands.' So much," says Pliny, "did he prize the finishing of Nicias" (*Tantum circumlitioni ejus tribuebat*). Now the whole force of this passage turns upon the meaning of the word *circumlitio.* In the dictionary this word is translated "polishing," as indeed its derivation points out. But the polychromists say that Praxiteles could not have meant polishing. Nicias, they say, was an encaustic painter, *i.e.* one who painted in wax, laid on with heat; and that therefore *circumlitio* must have meant painting the statues in encaustic. This, you see, however, contains no evidence, and may be taken as an example of what is called "begging the question." A little circuit perhaps may bring us round to a truer explanation of the passage. At times of festivity the Greeks delighted to oil their bodies, as did the Romans also—a somewhat barbarian practice, as it seems to us now, but so they did. To give a similar shine and gloss to their statues they occasionally waxed them, as the Romans did also. Nicias, as no doubt he used the best wax for his pictures, may probably have superintended this process for such of Praxiteles' statues as that sculptor prized the most; and there ends the whole story, for not a word is said about colour in it. Moreover, the question put to Praxiteles was rather a searching one—"Which of your statues do you like the best?" Also a direct answer might have given offence in some quarters. Thus however did he parry it gracefully, by saying, "Those which Nicias has had under his hands." The whole misapplication of this passage seems to arise, not from what Praxiteles himself said, but from what Pliny has volunteered: *Tantum circumlitioni ejus tribuebat*—"So much did he attribute (or ascribe) to the polishing of Nicias." The truth is, that it was a pretty *ad captandum* speech—one such as Pliny loved to record, and as such has been handed down with a force and meaning attached to it to which examination shows it has no claim.

In the two quotations I have made exist the principal strongholds of the statue-polychromists, as regards ancient authority of this kind in evidence of Greek practice. Having given precedence to these I will now proceed to mention one or two on the other side of the question.

In the discussion after the paper here on the occasion I have referred to, the Dean of St. Paul's brought forward a valuable, and to me a new passage, bearing on the subject—namely, one that occurs in line 406 of the Agamemnon of Æschylus, in which Iphigenia, when about to be sacrificed, is compared to a statue, "from the want of life or speculation in her eyes." "This simile," the Dean justly remarks, "would not have been used if the eyes of statues had usually been coloured."

Now, however, I would return to the practice of Praxiteles, so much advanced by the statue-polychromists. In support of Mr. Westmacott's views, in the course of the discussion on the occasion I have mentioned, I alluded briefly to the following illustration, which now however I will give a little more in detail in the following story. In the Ægean sea, not far removed from each other, are two islands, the island of Cos, and the island of

---

* From a paper read before the Society of Arts.

Cnidos. The inhabitants of the former island—that of Cos—desired to have a statue of Venus in the finest marble, and they commissioned Praxiteles to execute it. Anxious to give satisfaction, the sculptor in response made, not one statue, but two of this divinity, one nude, the other draped. Having done so, he gave his employers their choice. The inhabitants of Cos selected the draped version. Perhaps there was an Art Committee on the occasion, for, as it appears, they did not choose the best. At least, the other one, afterwards purchased by the inhabitants of the neighbouring island of Cnidos, became eventually by far the most celebrated of the two. At that time (about 300 or 400 years before our Saviour) pretty nearly every island in the Ægean had its celebrated statue of its tutelar divinity; but this Cnidian Venus was by far the most celebrated of all. It was however but life-size, was in Parian marble, and was no doubt exquisitely conceived and worked. A small temple was built for it in the midst of a beautiful garden: the temple was open on all sides, so that it could be seen in all views. The Cnidians valued it beyond all their possessions. The regard for it was not limited to them however,—Nicomedes, king of Bithynia, a neighbouring state, having offered to remit a very large public debt which the Cnidians had contracted with him, if he might become the possessor of it; but the offer was declined. Moreover, it was not merely "the cynosure of neighbouring eyes," but strangers came from all parts of the world to see it. "Many persons," says Pliny, whom I have been quoting *passim*, "sailed to Cnidos with no other object but to gaze on this statue. It was," he adds, "not only the finest statue of Praxiteles, but the finest statue in the world."

Now was this statue painted. Not a bit of it. At least not a word is mentioned of colour or tint in all Pliny's account of it, or in the still more detailed one by Lucian. Is it to be supposed that if the eyes, for instance, had been painted blue or brown, or the hair dark or fair, that neither of these two authorities would have made the slightest allusion to it? Pliny says that in every point of view this statue was beautiful, and that visitors remarked that, whichever way they approached her, "the goddess smiled benignantly upon them." Also Lucian, in his 'De Amore' (division 13, vol. v.) tells us that the mouth was a little open, and somewhat smiling. In another part he expatiates on the beauty of the hair and forehead, and admires the precise yet delicate eyebrows; but not a word about the colour of the hair and eyebrows. He then makes special mention of the swimming softness of the eyes, but not a word about their hue, which surely he would have mentioned had they been tinged, however slightly. The position of one hand of this statue was similar to that of the Venus de Medicis, as we see by some coins of Cnidos containing representations of her;—for alas! the statue itself no longer exists, having been taken away to Rome, and thence eventually to Constantinople, where it is said to have perished by fire. The other hand held a pendant of drapery, that fell over a vase, but there is no mention of colour on either of these accessories.

But the part of the evidence which is yet to come is far the most important, as it has direct reference to the surface of the undraped portions of the figure having been left untouched by colour. "This statue," Lucian adds, "was of Parian marble, and a blemish or stain on the left thigh was the more remarkable on account of the extraordinary brilliancy, (λαμπρυτης, or splendour) of the marble." This is the peculiar characteristic of Parian marble—far more beautiful than the Luna or Carrara marble we now use—and it illustrates that its native surface and hue were untouched. There is a very fine specimen of Parian marble in the British Museum, of a hand holding a butterfly, probably that of a Psyche, in this marble. There is an exquisite creamy, glowworm-like look about this marble that is most charming. It has just the degree of transparency of young flesh itself, and possesses, as it were, a native semi-lucency of its own, like that of the Milky Way, or of a summer sea.

Let us however look to the further pertinence of Lucian's description. There was a stain on the marble, he says; but adds, that the effect of this was only like that of a foil, which rendered the brilliancy of the rest of the marble more remarkable. Now, however much this fancied foil, but real blemish, was converted into an additional charm by the lover-like attachment and consequent special pleading of the admirers of this cherished work, you may be sure that the sculptor himself, when he made it, was not of this way of thinking. Solicitous as we sculptors are to obtain the purest and most spotless marble, especially for this class of work, we may be quite sure that Praxiteles would have been very glad, if he could, to have concealed the blemish in question; and that if his friend Nicias had really been in the habit of colouring his statues, it was on an occasion like this that his services would have been especially in requisition.

Painted therefore, as regards the flesh, it certainly appears that this *chef-d'œuvre* of ancient art was not, or the blemish in question would have been the first thing to have been concealed. Neither could it have been stained, both because there is no mention of this, but also the word λαμπροτης is conclusive on this point. And I would submit that it were as vain to paint the lily, or gild refined gold, or varnish a diamond, as to attempt to add to the poetry of pure Parian marble by any colour enhancement whatever.

When also this remarkable instance of the non-colouring of this celebrated work of ancient art is brought to bear upon the general practice of those times in respect to colouring marble statues, the evidence afforded by the passages I have quoted is the stronger just because it is negative. Had Pliny or Lucian felt called on to say that the Venus of Cnidos was not painted or stained, it might have been argued that she was an exception to a rule that otherwise prevailed; but not a word appears on this subject. Instead of this, both writers treat the matter just as we should now, or at any other time when the painting of marble statues has been, as now, not the general practice. There are various other points which, having been gone into before, I avoid repeating, and I rather look to upholding my views by contrasting two, as it has happened, on each side, of the principal passages on this subject, than by an elaborate array of various authorities. Nevertheless, I am prepared to allow that Archaic and Æginsetan sculpture may have been frequently treated with direct colour, both from the force of old precedent, and from each art, painting and sculpture, not having been originally sufficiently advanced to go alone. But assuredly I do not believe, as indeed there is no proof, that in the best times of Greek art independent marble statues were ever painted, nor indeed any highly-wrought statues at all painted, except for purposes of idolatry. And this brings me at once to the proposition I have to put before you. It is this—that the ancient Greek statues were only painted when they were idols, and when they were intended to be worshipped; and thus, when these statues were painted in Greece, that it was priestcraft and not art-craft that painted them.

Having now laid this distinct proposition before you, for you to consider whether it is right or wrong, I will proceed more in detail. Doubtless there were many ancient Greek statues that at any rate were not monochrome, but on the other hand, of various colours, and in many cases I believe painted up to full tints. These however were not, I conceive, usually in marble, but their chief examples come under the head of the chrys-elephantine art of the Greeks used in the temples. These Greeks, like the Egyptians, made gigantic statues of their gods—Jupiter, Juno, Minerva, Apollo, &c., not however in granite, but sometimes in marble. Usually however these very large figures were made in metal, either cast or beaten work, or in ivory and gold, that is, with a surface of thin veneers of ivory and plates of gold laid over a framework of wood, so fashioned as just to allow their thickness to make up the substance, form, and surface required. This seems, no doubt, a strange patchwork-way of making up a god, like a piece of upholstery, and vastly inferior in dignity to hewing him out of granite or marble; and indeed, had we not reliable data for the practice, we could hardly have believed that such a people as the Greeks would have so wrought. However, as my audience are not perhaps conversant with Quatremère de Quincy's or Müller's account of these proceedings, I will give a few sentences on the subject drawn from what they say. First, I would premise that these chrys-elephantine, or gold and ivory statues, were not uncommon in Greece and the Grecian islands, —indeed, that it was a received way of making a god in those days; and that moreover they were not unfrequently of great size. The Jupiter of Elis, although seated, was 60 feet high; and the Minerva of the Parthenon, standing, 40 feet. Both of these were by Phidias. Among various other large examples of this art were the Juno of Argos, by Polycletus; the Æsculapius at Epidauras, by Thasymedes; and the "Great Goddesses" at Megalopolis, by Damaphoon.

The first thing to be done in making these giant works, after the model was prepared, was to put together a great framework of wood as a core, yet hollow within so that the workmen could get inside to adjust the work and rivet the veneers of ivory and gold which were to form the surface; and no doubt for convenience they had stages and staircases within these great statues, the wooden framework of which was, as Müller informs us, strengthened across with rods of metal. But he shall speak for himself: in division 312 of his elaborate work on ancient art, this author thus informs us:—"The ancients received from India, but especially from Africa, elephants' teeth of considerable size, by the splitting and bending of which, 'a lost art,' but one which certainly existed in antiquity, they could obtain plates of ivory from 12 to 20 inches in breadth." I may here be allowed to remark that in the Exhibition of 1851 this "lost art," so called by Müller, seemed to have been revived, and carried even further than by the Greeks. A prize medal was awarded on that occasion to Messrs. J. Pratt and Co., Meridan, Connecticut, United States, for specimens of ivory veneers cut by machinery. "These veneers were exceedingly delicate"—I am quoting the official report—"one piece alone being 12 inches in breadth and 40 feet in length, and having been sawn from a single tusk." Perhaps some of those present may remember this remarkable example of the ingenuity of our brothers over the water, pendent spirally, like a great carpenter's shaving. But to return to these great Greek statues. "In executing one of these," says Müller, "after the surface of the model was distributed in such a way as could best be reproduced in these plates, the individual portions were accurately represented by sawing, planing, and filing the ivory, and afterwards joined together, especially by the use of isinglass, over a kernel of wood and metal rods. The holding together however," he adds, "of the pieces required incessant care;" as indeed we may well conceive, as ivory is apt to expand and contract, and warp and curl, in changes of moisture and temperature. Indeed, it must be acknowledged that the whole process and sham nature of the work thus described impresses us with want of dignity, lack of permanence, and the necessity of repair. From a passage in Valerius Maximus, it appears that Phidias desired to make the figure of Minerva for the Parthenon, not after this fashion, but in marble: he was however overruled. Had the sculptor had his way, we should probably have had now existing some grand and noble remains of it, in addition to those invaluable fragments of some of the subordinate statues which we possess in the British Museum. But the priests had their will. Idolatry had its way instead of art, and in consequence—oh, just retribution!—not a pinch of dust remains of their daughter of Jove. Now, *cæteris paribus*, the priests must, we suppose, have desired permanence for their god, and must have been well aware that this upholstery-manufacture mode of making it was not likely to last like marble. Also, this mode could not have been selected, as has been suggested, merely because of its superior costliness, because the introduction to a greater degree of gems with the gold, as was sometimes done, would easily have made the marble work as costly as, or more so than the ivory. Also, the untouched surface of ivory is by no means more beautiful as a representation of flesh than marble,—much less so indeed as regards permanence, as it gets yellow and discoloured. But then, on the other hand, it is highly suitable for receiving the most delicate and pure tints: it is therefore much used by miniature painters. Most of the beautiful works exhibited last year in this room, of the late Sir William Ross, were painted on this material. It is probable however that the ivory surfaces of these colossal statues were rather stained than painted; and ivory takes these stains evenly and with facility, which marble does not. The examples indeed which I have seen of colouring marble, especially with tinted wax, have been singularly unfortunate. Marble is apt to be unequal in its grain, and takes the colouring matter capriciously. In the imitation of flesh a greasy unpleasant effect is the result, and where the grain of the marble shows coarsely, what is vulgarly called a "goose-flesh" appearance is produced, which is certainly neither agreeable nor divine. Doubtless the Greeks imagined that their gods had pure complexions as well as beautiful features. The empyrean airs of heaven might well be supposed to imbue these with an exquisite delicacy not to be imitated by the permanent treatment of any surface less capable of refined tints than ivory. I am well aware that in the few last sentences I have been hazarding a somewhat novel theory, in this special reason I have submitted for the use of ivory in the colossal idol art of the Greeks, but pray accept the explanation that I do this not dogmatically, but only for discussion.

Even however in entertaining this view of the great statues of the presiding genii of the Greek temples having been thus surfaced with ivory for the purpose of being coloured up to a refined version of the tints of nature, we must not be under the impression that they had a common vulgar effect, like that of wax figures, for which we have an instinctive repugnance. This indeed would have defeated the very object which the priests had in view—that of impressing the multitude. Indeed, in as far as it could work at such a disadvantage, no doubt the exquisite taste of the Greeks was also applied to the finish of these works. The Minerva of the Parthenon was no mere sham of a great woman, but in the hands of Phidias was a bold though coerced attempt to realise the tutelar divinity of Athens, the immortal virgin of Wisdom—a being solemn and impassive, far above the human level, and through whose veins coursed, not blood, but celestial ichor.

Dramatic effect in their worship was ever sought by the Greeks, and it was only at special times that their divinities were unveiled at all to the general people. On such occasions every means was taken to work upon the senses. Coloured curtains tinted the light, ceremony lent its impression, and music and the chant their charm. Censers filled the air with their ambrosial vapour, and sacrificial clouds waved before the divinity, like those of his own imaginary heaven, from behind which, to the entranced votary, well might the mystic god almost or quite seem to breathe, frown, or smile. This was a "consummation devoutly to be wished" by the priests, for then the fame of their god increased, and offerings flowed into their treasury. To effect impressions like these doubtless was it that these great statues were painted up to a key of divine life which assuredly could not have been reached by the mere natural tints of ivory and gold. It was to accomplish this that the powers of such as Phidias were thus coerced, and it was under all these devices that these magnificent idols were manufactured in those old days as the agents of polytheism and superstition. Whenever, also, the statue of the god himself, in the penetralia of his own marble house, was thus treated with the hues of life, doubtless its own immediate subordinates around, especially within the building, had in some degree to wear his livery. Also, when polychromy spread in addition over the exterior architecture, harmony dictated that some variation of colour should be connected also with the outside sculpture, as especially in the backgrounds of the tympana, metopes, and friezes. As regards however the statues themselves in these situations, the variety of tint was probably confined to that obtained by difference of material, as in shields, swords, helmets, and bridles of metal, and not by added surface colour, requiring constant and extensive repairs not capable of being done in secret, as was the case with the interior figures.

Thus do I conceive that the Greeks did colour some of their statues, and that they did so in different degrees, which however may be divided into two general styles of execution. One was the painting or staining them more or less to imitate reality, for the higher classes of which work it was, I conceive, that ivory was used, as in the great gods of the temples. The second was the obtaining of variety of colour by difference of material. The former of these treatments can only, I conceive, find its excuse, if excuse it may be called, in the idolatry of the time. The second partakes of the character of mosaic work, and is perhaps less objectionable in principle; but as an art it is assuredly more curious than beautiful, as may be remarked of several late experiments in this direction by our neighbours the French.

While however it may be readily acknowledged that Greek artists, coerced by polytheism and superstition, did occasionally colour some of their most prized works; yet on the other hand, with respect to the highest class of their independent marble statues, it is equally evident that they were left untouched in this respect, as we have seen was the case with that most cherished work of them all, "the Venus of Cnidos."

I would thus submit that Greek art-craft made beautiful statues—uncoloured—as works of art, and left them so; and that it was Greek priestcraft that made them coloured—as idols, and as engines of state religion. This is a broad distinction: as such I venture to submit it to you as a clue to what I readily acknowledge to have been the varied character of old Greek practice in this respect.

We will now proceed to later times. Here the reflection obtrudes itself upon us, that even now we meet occasionally with coloured statues which savour of superstition; but I would avoid this phase of the subject, and as regards modern times restrict myself solely to the art-craft of the question. In the Renaissance, or revival of the arts in Europe, we hear nothing of colouring marble statues. In the time of the learned Leonardo da Vinci, Michael Angelo, Raffaelle, John of Bologna, and others great in art, we find no instance of marble statues having been coloured. Michael Angelo, who was so remarkable for the union in his one person of all the arts, being at the same time an admirable architect, painter, sculptor, and decorator, never attempted to colour his marble statues. It is true that colouring was afterwards applied to statues and relievi, even of considerable size, by Luca della Robbia and others; but these works were not in marble, but in porcelain, and more subordinate than any fine work of sculpture can ever be, however harmonious with the situation in which it is placed. The marble Moses for the tomb of Julius, and the wonderful groups of the Medici monuments, have come down to us in their native monochrome, untouched by change of tint, except such as time has supplied. Michael Angelo, that representative in one of all the arts of his time, did not mingle in one object the two arts; nor does it appear that in the more important works of the Cinquecento, marble statues were ever coloured; nor, great as was the attention given to the works of ancient sculpture that at this period were from time to time discovered among the ruins of Italian towns, especially in that of ancient Rome, does it appear that these great masters ever contemplated the idea that such works were ever coloured. It appears therefore improbable that any remains of colour were found on the Apollo, the Venus, the Laocoon, or other celebrated works when first exhumed; nor does any colour seem to have been found on the statues in Herculaneum and Pompeii, although the colours on the walls of the apartments in which they were discovered were still fresh and vivid. Thus neither in ancient nor modern Italy does there appear any proof of the prevalence at any time of the colouring of independent marble statues, any more than in Greece.

Having thus set forth my view as to the practice of the ancient Greeks in this respect—namely, that they did not colour their statues except for purposes of idolatry, for which reason we find this treatment only connected with their temple architecture, and that not always, we naturally come to the consideration as to whether we should colour our statues. At any rate, in these isles we are not idolaters. Our church is not one of idolatry; and therefore we have not, as I said before, that excuse, such as it is, for colouring statues that the Pagans had.

Quitting however for a moment this vantage ground, let us consider the matter merely as an art question. Let us first consider, is the addition of colouring to statues to be looked upon as an advance in art, or a retrogression? The polychromists will of course hold it to be the former, while the monochromist in sculpture will represent that it is rather a confusion of those arts which good taste has gradually separated in the progress of civilisation into distinct languages of human expression. The polychromist will claim honour for uniting the charms of colour with those of form, as the evidence of advance and improvement, while the monochromist will point with a significant finger to the earliest efforts of art, when the arts of form and colour, each barely sufficient in itself to suggest even an animal, a man, or a god, were obliged to club their means to produce anything like a clear result. We are not without illustrations of this even now, in our most inferior specimens of pottery, sold about the country to cottagers by "Cheap Johns," in crude little images of children, dogs, and parrots, &c., of which the form is so incomplete that the intention could hardly be recognised but for the aid of colour.

In primæval times the first thing that men attempted in art was probably in the way of hero worship, in the making of images of their ancestors, or of great tyrants, as a sort of guardians to their houses, and to be prayed to and propitiated in the chase or war. The more living these could be made to look by the artist's hand, and the more ferocious, the more effective no doubt was deemed their mystic power, and hence from these beginnings arose that evil feature that has played so large and lamentable a part in the history of man—the idol. This form of superstition we have I trust thrown off for ever, except in a region in which I have no doubt we shall all allow there is no objection to it—in the nursery—where it appears with but little change of name, in the form of the doll. Doll is only an abbreviation of idol. It is an infantine abbreviation: it is the way a little child would strive to say idol. In the original Greek the word is Ειδωλον; in the Latin, *idolum*; in the English, idol; and in the nursery, doll. You may recognise readily that these little images are, to all effects and purposes, coloured statues. Also, we may say that in the nursery they are to a great degree worshipped, especially when they are new: a new doll is to a certain degree a divinity for the time being. However, these kinds of idols are no longer "ferocious." On the contrary, they are produced as pretty as wax and carmine and silken tresses can make them. They even open and shut their eyes, which is an advance even beyond the cruseo-elephantine statues of the ancients. At least, I have no recollection of any record of winking divinities in those days. We can have no objection to the harmless and interesting idolatry of the nursery towards these little images: there is nothing that breaks any commandment in that. I would here remark that these little figures possess one great advantage over any coloured marble statues that I have seen—namely, in having eyelashes. The want of these natural and beautiful fringes to the eye in such coloured marble statues as I have seen is very unpleasing. Of course in a pure marble statue you do not feel this, but when coloured the want is sadly apparent, and I do not see how it can be got over. There are some evidences of bronze eyelashes having been added in some of the ancient works, but the effect of these could not be very happy, one would think. The children's favourites are more fortunate in this respect. Pray do not conceive that I introduce these nursery statuettes in any way for the purpose of throwing ridicule upon the subject of coloured statues, but only as an illustration of the sole phase of the "coloured statue" which I conceive to be at the present time legitimate as a matter of art or regard.

However, I must not let this happier phase of the idol draw me away from our view of the original type, or from the broad consideration I desire to illustrate—namely, that all barbarians and idolaters have been and are more or less polychromists as regards the art of sculpture. They have all coloured, and while they remain barbarians and idolaters will continue to colour, their statues.

I conceive therefore that in these civilised days the colouring of statues is not an advance, but a palpable retrogression towards earlier times of less intelligence and of a lower dispensation; and moreover, as far as art is concerned, that a decadence would at once ensue on a general adoption of such a practice. A coloured statue or bust now and then can do no harm, but perhaps rather good, as they may serve to show they will not do. But there is a great deal of fashion in art. Fashion is often very unreasonable, and if a fashion were to set in for idols instead of statues, I believe it would do for the time a deal of mischief. Moreover, as a matter of sense and probability, is it possible to consider that the uncoloured statues of the Venus of Cnidos, and of the Moses and Night and Morning of Michael Angelo, and the noble works of Thorwaldsen and Flaxman, are but incomplete steps, half-way as it were (and as having left the true track of the arts) between the first struggling idolatrous attempts when images were all painted—and a more advanced and perfect period, forsooth, when the same barbaric principles are to be reproduced and practised?

INSTITUTION OF CIVIL ENGINEERS.

GEORGE P. BIDDER, Esq., President, in the Chair.

April 16.—The paper read was "*On the Floating Railway across the Forth and Tay Ferries.*" By WILLIAM HALL, A. Inst. C.E.

The works described in this paper were undertaken in connection with the Edinburgh, Perth, and Dundee Railway, for the purpose of establishing an unbroken communication between Edinburgh and the country north of the Tay, by which goods (and even passengers if required) could be conveyed across the ferries without removal from the waggons.

One of the chief difficulties which had to be overcome arose from the difference in the levels of low and high water, averaging 16 feet at spring tides. Several plans were proposed: among others hydraulic and steam cranes, to lift or lower the waggons, but it was considered that this would be too slow a process, as well as be liable to damage the waggons. Another design proposed girders 100 feet in length, having one end hinged on shore, and the other attached to a floating caisson, to rise and fall with the tide; but owing to the exposed situation this would have rendered necessary the construction of costly protecting piers and jetties.

The works actually carried out at the Forth Ferry consisted, on the east or sea-side of the piers at Granton and at Burntisland, of a slipway, having an inclination of 1 in 6, and constructed of solid masonry. Rails were laid upon this slipway, on which traversed a heavy platform, of a wedge shape, the upper surface being always horizontal. This platform was 65 feet in length and 21 feet in breadth, and was formed of a wooden framework, having four main longitudinal timbers, into which rails were sunk. The platform rested upon twenty-four cast-iron wheels, each 30 inches in diameter, with a flange cast on the middle of the rim, so as to allow the wheels to bear evenly on both sides of the rails. To the sea-end of this travelling platform were attached, by means of universal joints, four wrought-iron trough girders, for spanning the distance between the platform and the stern of the vessel. The girders were raised or lowered as required, by two powerful winch crabs, placed on a staging elevated above the platform, at about the middle of its length. The two chains, one on each side, for lifting the girders, were passed round the barrels of the crabs, and thence over two derricks to the ends of the girders, counterbalance weights being attached to the other ends of the chains. To provide for the safety of the platform, in the event of the fracture of the hauling chain, two lines of racks were laid along the surface of the slipway, into which worked palls, attached to the axles of the wheels. Steel points turning on hinges were attached to the ends of the girders, and also to the pier-ends of the main timbers of the platform, to prevent an abrupt transition of the waggons to or from the vessel. Each of the universal joints by which the girders were attached to the platform consisted of a bolt or pivot 3½ inches in diameter, the middle of which was ball-shaped, and worked in a corresponding portion of a cup or socket. This socket was circular, and was made in two parts, having a projecting collar and flanges, which were clipped by and were bolted to the plates fixed to the main timbers of the platform. The socket was shaped in a radial form, to allow the pivot full play, and to permit of the ends of the girders moving 3 feet on each side. By these means a range of position was obtained to the extent of 6 feet, to compensate for the pitching or rolling of the vessel.

A stationary steam-engine of 30 H.P., similar to a locomotive with the wheels removed, was fixed on the quay, for raising or lowering the platform and for drawing the waggons off the vessel. On the crank-shaft of the engine was fixed a pinion working into a wheel, on the shaft of which were three winding drums, one placed in the middle of each line of rails, and one in the centre of the intermediate space. The winding drums were 2 ft. 10 in. in diameter, with flanges, on the periphery of which wood was bolted, and round which there was a wrought-iron friction band acting as a break. The speed of the engine was decreased by toothed wheels and pinions; seventy strokes of the engine giving thirty-five revolutions to the drums, and, by other intermediate wheels and pinions, three revolutions and one-fifth to the chain-wheel. The weight of the platform was about 70 tons, and it was moved up and down the incline at a velocity of 18 feet per minute.

The steam-vessel, named the Leviathan, for conveying the goods traffic across the Forth, was built by Mr. R. Napier. It was constructed of iron, 172 feet long, 54¼ feet in breadth over and 34 feet between the paddle-wheels, with 11 feet depth of hold. The draught of water when loaded was 6½ feet, and when unloaded 4¾ feet. The vessel was propelled by two steeple-engines, each working its own paddle, of the collective nominal power of 210 H.P. On the deck there was standage for three lines of waggons, the end ones on each line being "scotched." The description of rail used throughout was the inverted bridge-rail, weighing 53 lb. to the yard, the same as on the Granton Pier; and they were sunk into the longitudinal timbers so as to be flush with the surface of the deck.

The works at Granton and Burntisland, on the Forth, including the slipways, platforms, stationary engines, and gearing, cost £10,000, and the Leviathan complete, £16,226. The working expenses for six months, ending July last, were £768 for the stationary engines and machinery, and £1305 for the vessel.

The Leviathan generally made from four to five double trips, a distance each way of 5½ miles, in the day of twenty-four hours, and could take from thirty to thirty-five waggons at a time. During the last six months 37,618 trucks had been so conveyed across the Forth. The time occupied in making a single trip was twenty-six minutes, and the operations of loading and unloading were performed in from five to eight minutes.

At the Tay Ferry, some modifications suggested by experience were made. The inclination of the slipway was 1 in 8, and it was formed of timbers resting upon wooden piles. The length of the ferry was only ⅞ths of a mile. The vessel, the Napier, was 140 feet in length, 40¾ feet in breadth over and 22 feet clear between the paddle-wheels; and she was propelled by a pair of oscillating engines of 112 H.P. There were two lines of rails on the deck, with standage for fifteen waggons. The vessel made from six to seven double trips, and carried on an average one hundred and eighty waggons per day. The works cost, including the slipways, platforms, stationary engines, and gearing, £8800; and the vessel Napier complete, £9182.

The works were designed by Mr. Bouch, M. Inst. C.E., and were executed under his directions by the author; Messrs. Anderson being the contractors for working the ferries.

In conclusion, the author remarked that the "floating railway" might be adopted with advantage in all places where the expense of a bridge or a tunnel offered an insurmountable obstacle, or where the navigation would not admit of interruption by the erection of a bridge, as at the Mersey and Bristol Channels, and across the Straits of Dover.

April 23.—The paper read was "*On the National Defences.*" By G. P. BIDDER, jun., B.A.

The author commenced by stating that it was not his intention to offer any opinions or to propose any schemes of his own, or to dogmatise on those of others; but merely to bring together and arrange the several questions requiring consideration, so as to facilitate their discussion. The subject was one of intricacy, from the changes which modern improvements were necessitating in the art of warfare and in the means of defence, as well as from the apparent want of any clearly defined principles of construction. Its importance was undeniable, and might be judged of from the fact, that during the last eight years £29,000,000 had been expended in the maintenance and reconstruction alone of the navy—about £8,000,000 representing the value of new ships—besides which £12,000,000 had been recently voted for the construction of military coast defences.

The first question which arose was, whether reliance should be placed on the navy alone, and the energies of the country be devoted to the task of rendering it of such a character and strength as would insure to Great Britain the mastery of the seas, especially of those surrounding these islands; or, whether a part of the resources of the nation should be employed in providing a supplementary protection to the shores, by means of land fortifications. The insular position of Great Britain rendered it peculiarly liable to invasion at a great number of points, which could not all be protected by land fortifications. But an enemy making such an attempt must have ample means of transport, as well as convenient ports of embarkation. Now on the French coast there were but three ports fit for such a purpose—Cherbourg, Brest, and L'Orient; and there were not any others between the Cattegat and the coast of Portugal, excepting Flushing. Again, if the Russian fleet desired to combine with that of France, it would have to force a passage through the Straits of Dover, or sail round the whole of the island. The substitution of steam ships for sailing vessels, while it increased the rapidity and certainty with which troops could be transported, at the same time augmented the efficiency of a marine force in protecting a given extent of coast, and gave greater facilities for watching or blockading an enemy's ports, as well as for conveying intelligence. There was scarcely a point round the extensive seaboard of this kingdom without an adjacent port or harbour, capable of being rendered fit at a moderate cost for the reception of vessels of war, for replenishing stores and ammunition. Added to which, the railway system would enable an unlimited supply of coal, of ammunition, and of warlike stores, to be conveyed to these harbours at the shortest notice; and would place the entire mineral and mechanical resources of the country at the disposal of the government. These facts were important, as in future warfare a base of operations must be provided for a fleet, as formerly for an army, and the naval base must rest on an ample supply of coal.

As the main strength of Great Britain lay in her exhaustless mineral resources and numberless harbours, so the chief strength of the power from which alone invasion might be feared lay in its enormous army. A good steam fleet interposed a barrier which must be destroyed before an invading expedition could be despatched with a chance of success. Such an enterprise as an invasion would seem hopeless in the face of a quick, vigilant, and powerful fleet. But if that fleet were worsted the enemy would have all the advantage of his superior military organisation. Such a contingency should be provided for by improvements in the coast lines of railway; and if it occurred, the labouring power of the country should be employed in throwing up earthworks, in destroying roads and bridges, and in impeding the advance of an invading army,—a service in which the members of the Institution might be made eminently useful.

It was contended that any attempt to protect the shores generally, by the erection of land fortifications, must be hopeless, on the ground of expense alone. The question therefore reduced itself to the advisability of fortifying the dockyards and arsenals, and possibly two or three other places palpably open to invasion. This could only be effected at great cost, and the forts when erected would require a large number of troops to man them. If the same amount of money were employed in the construction of additional ships of war, this end might be answered quite as effectually; and an attack on the arsenals could scarcely be contemplated so long as the Channel fleet remained intact.

Assuming then that it was considered essential to render the Channel fleet as strong and as effective as possible, it was submitted, having regard to the modern improvements in gunnery, and the application of steam power to propulsion, that vessels of war should be adapted to utilise and develope to the greatest extent the peculiar resources of this country—iron and coal. That they should also be adapted to economise the actual supply of effective seamen. That they should be designed to attain the highest speed consistent with other qualities, by giving them finer lines and greater length, such as it was hopeless to attempt with the heavy bluff bows at present in favour. As to the material which should be used in the future navy, it had been proved that the present vessels were indequate to support the additional weight imposed on them; and it was well known that there was an increasing scarcity of wood suitable for ship-building purposes. On the other hand, there was at home an inexhaustible supply of iron, and the skilled labour for producing iron ships. The principal objections to the use of iron were then noticed; and it was remarked that the destructive effects of both shot and shell were now of much greater importance than the secondary effects produced by splinters. The advantages in the use of iron were, the greater strength attainable, the comparatively little repair and renovation required, and the freedom from danger or loss by fire.

The next point was, the much-vexed question of the fortification of ships of war by means of iron plates. It had been ascertained that a thickness of iron of at least 5 inches was required to resist completely the heavier description of shot. It was clear that such a defensive armour would involve an immense addition to the weight of a ship, and must greatly impair her efficiency in other respects. Allusion was then made to the two notable examples of this system—the French vessel La Gloire, and the English ship the Warrior, the former of which was admitted to be a successful and formidable vessel, and the latter, although much larger, was but partially fortified, having her extremities unprotected. This, it had been asserted, was to render her more seaworthy; but if a necessity, which was more than doubtful, it was a great imperfection in the system. It was clear that if the Warrior had been constructed of the same proportions, with plates throughout of the same thickness, she would have been a faster ship and more seaworthy than La Gloire, on account of her greater size. It was also suggested whether the removal of the spar-deck would not so lighten the Warrior, as to admit of the extremities being plated uniformly with the sides, without in any way impairing its efficiency. The guns would then be worked entirely from the spar-deck, free from the obstruction of smoke. The bulwarks might be made sufficiently high and staunch to afford complete protection to the men. In such a ship, it was contended, the spars and rigging should be of a subordinate description. But on this subject of the fortification of ships, it was still a matter for inquiry whether the greatest general efficiency would not be obtained by adopting the system of protective armour on a more moderate scale.

Another point bearing on this question was, whether, owing to the greater range and accuracy of ordnance, naval engagements would not necessarily be fought at longer distances than formerly. As at long ranges the height of a target was more important than its breadth, this seemed to show the propriety of reducing ships to single decks, making them as low in the water as possible.

If these considerations were correct, it was submitted that they indicated as the proper description of vessels to be employed for Channel service, iron vessels built of great length, having fine lines and considerable power to insure speed, and carrying an armament of very heavy guns on the spar-deck alone. That they should be as low in the water as was consistent with safety, and be protected by plates of moderate thickness throughout their whole length; and that they should be fitted with spars and rigging of the lightest description.

As to "steam rams," it could hardly be doubted that if properly constructed, and of sufficient size, power, and speed, their effect among a hostile fleet, especially a fleet of transports, would be terrific. Any attempt, however, to combine the qualities of a "ram" with those of a fighting ship would only impair its efficiency. The expense attending the construction of these "rams" would be very great, and the service would be very dangerous; but still it might be advantageous to construct these "rams," if by their means three or four of the enemy's ships could be destroyed before the ram itself.

Attention was next directed to the best mode of dealing with the present navy, and of converting the old men-of-war into efficient ships. The usual plan was to lengthen them, and to put in powerful engines, and an armament of heavy guns of the same number as before; but it was suggested whether it would not be a wiser course to cut them down, so as to have all the guns on one—the spar—deck, and to dispense with the heavy spars and rigging. This would reduce the weight sufficiently to compensate for the addition of the engines, and perhaps to admit of the fortification of the sides; while, by bringing the vessel higher out of the water, it would give a finer line of flotation.

It was noticed that the subject of the paper being "The National Defences," the observations on ships had been exclusively confined to those intended for service in the home seas; and was therefore not necessarily applicable to the case of vessels required for foreign stations.

REVIEWS.

The English Cathedral of the Nineteenth Century. By A. J. B. Beresford Hope, M.A., D.C.L. With illustrations.—London: John Murray. 1861. 8vo. pp. 282.

This work can scarcely fail to attract very general notice, from the interest of its subject and the known ability of its author. To most readers, perhaps to all, it will be found fully to bear out any anticipations which the announcement of it may have raised; and on many accounts an extensive circulation, and more attention than falls to the lot of many works on architectural subjects, may fairly be anticipated: the more so, perhaps, that Mr. Beresford Hope's work is by no means entirely architectural, nor even in the technical sense of the word entirely ecclesiological. It takes a broad view of a subject interesting to a large proportion of the intelligent part of the community; and while there is enough of architecture to commend the volume to a professional eye, there is not so much as to incommode ordinary readers.

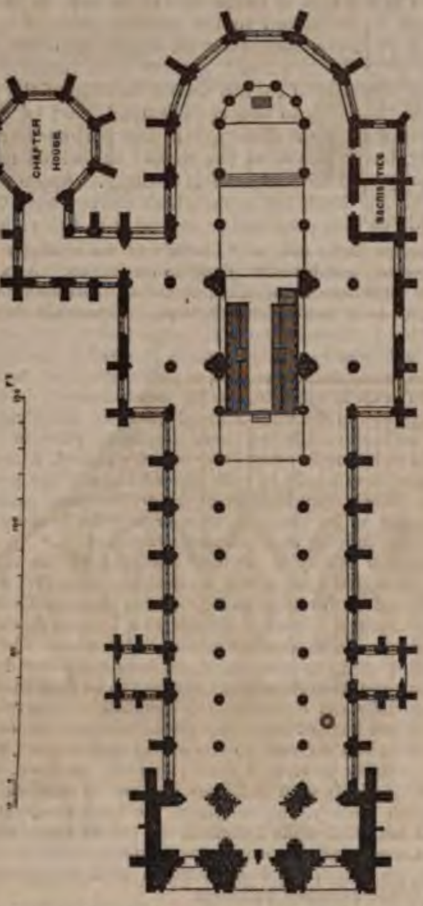
By "The English Cathedral" Mr. Beresford Hope intends to convey not merely the idea of a cathedral as a building, but also of the cathedral institution as connected with episcopacy; and the argument running through the work may be concisely stated to be something like this:—If the Church of England is extending and to extend in this country and our colonies, we require, to organise and regulate and direct that movement, new bishops, not merely for the colonies, but also at home; and, for reasons which are stated at considerable length, if these bishoprics be established, new cathedrals should be constituted. Thus, having brought us to the idea of cathedrals to be built in the nineteenth century, and to be suited to the requirements of that century, the author inquires, somewhat in detail, into the peculiarities that such a building should present—an investigation which involves, as a matter of course, a consideration of the peculiarities of all cathedrals. Into the ecclesiastical part of the question, here treated with great ability, it is not perhaps our province to enter fully, but it lies so at the root of the whole matter that it will not be proper to disregard it entirely. Among the opening sentences of the book are some which convey well the aspect of the question as it is proposed to regard it in the volume.

> "A cathedral is, as everyone knows who has thought ever so little upon the matter, both a building and an institution. As a building it is supposed to fulfil certain architectural and artistic conditions; and, as an institution, to carry out certain religious and charitable objects. It follows from this double nature of a cathedral that the subject of Cathedral Extension in England—a subject which has within the last thirty years occupied no inconsiderable portion of public attention, and which is not likely in the years to come to lose its importance—is in one aspect an architectural, and in the other a social question, according as the building or the institution fills the more prominent place in the inquirer's mind. But in this as in every other mixed question, it is neither possible nor desirable so wholly to void either nature of the presence of the other as to leave it open to treat of the architectural cathedral without some reference to its practical uses, or to point to those uses without treating of the building in which they are embodied. . . .
>
> "Westminster Abbey is a quasi-cathedral of the thirteenth, and St. Paul's an actual one of the seventeenth century; while the idea which I propose to develope is that of the English Cathedral of the Nineteenth Century. In adopting this title I desire that every word of it should be taken in an absolute and exclusive sense. The building and the institution are to be a cathedral, as distinct from and opposed to a parish church and its organisation; they are to be English—English that is, both nationally and ecclesiastically—as distinct from and opposed to foreign; and last but not least, they are to be of the nineteenth century, as distinct from and opposed to one of any earlier age. Keeping these limitations steadily in view, I shall endeavour to show, not only that there are distinctively such buildings *in posse* as English cathedrals of the nineteenth century, but that there are good practical reasons why they should be built; while I shall, in the second place, suggest certain data of size, character, and arrangement which ought, in my judgment, to regulate the architectural construction both of the churches themselves and of the accessory buildings."

There are some pages of argument as to the desirableness of an extension of the episcopal system, but none at all as to whether the style of the buildings shall be Gothic or Classic. "I take leave," says the writer, "to beg the first and most important consideration, by assuming that, *pace* Lord Palmerston, the building must be an exhibition of some phase of that style of architecture commonly called Gothic or Pointed." Perhaps on the whole this course has been wisely adopted; it narrows the scope of argument by assuming a certain basis as admitted: and for those by whom bishops are held cheap, and Classic architecture is preferred to Gothic, this book is not written. On the question of the cathedral system, as a desirable adjunct to all bishoprics, there is much to be urged, and Mr. Beresford Hope makes out a strong case in favour of the constitution of chapters, and the erection, or appropriation where they already exist, of suitable cathedrals,—buildings which shall possess not only the ritual arrangements, but also the dignity proper to such structures, and which is well characterised in the following sentence:—"A cathedral ordinarily exhibits an excess of length, and height, and breadth—a profusion, so to speak, of plan—a stateliness of ornamentation, an increment of dignity in its appearance, which lifts it above the level of the ordinary church."

Having now introduced the book and disposed of its preliminary matter, we shall proceed as far as space permits to consider the more architectural portion of the work, in which the subjects that come under review are the following:—The most proper variety of Gothic to work in; the cathedrals actually built or projected for modern Anglican use; the contrast between Roman Catholic and Protestant cathedrals; the history and characteristic features of the building; its decoration and its adjuncts.

Perhaps one of the most interesting sections of this volume is that devoted to actual examples: among these occur St. Ninian's Cathedral at Perth, by Mr. Butterfield (actually built); Kilmore Cathedral, by Mr. Slater (actually built); Inverness Cathedral, by Carpenter (design); Colombo Cathedral, by the same (design); Brisbane Cathedral, by Mr. Burges (design);—St. Kitt's Church, by Mr. Slater (actually built); Memorial Church at Constantinople, the design by Mr. Burges now being carried out, and also the nobler design of Mr. Street;—St. Nicholas' Church, Hamburgh, by Mr. Scott (in course of erection); Calcutta Cathedral; Sydney Cathedral. Besides these, various other examples are given; but of all those named at least the ground plan is given, and of several there are other illustrations.



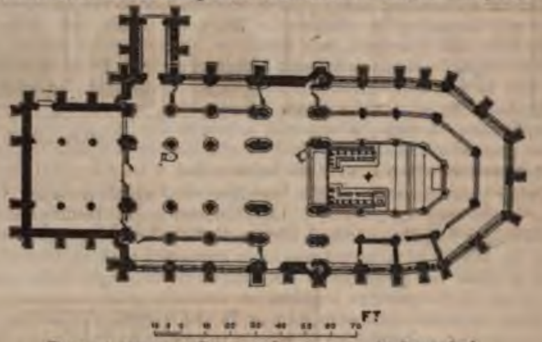
Plan of Inverness Cathedral. 75 feet to inch.

We are enabled by the courtesy of the publisher to present our readers with a liberal specimen of the illustrations with which the work is embellished, and by which its value is greatly enhanced. Of these perhaps none are more interesting than those embodying the as yet unexecuted designs of Mr. Burges for Brisbane Cathedral, a structure which we may yet hope to see raised, and of which a plan, section, and elevation are given.

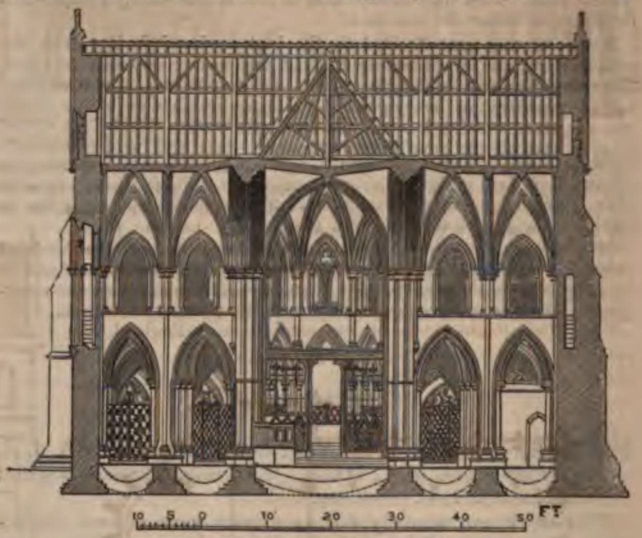
The noble design for Colombo Cathedral, which we transfer from Mr. Beresford Hope's pages, has been, it appears, superseded, and consequently there is every probability that its publication in the work before us will be the most enduring memorial that it will receive; while of the grandiose design for Inverness Cathedral—also from the pencil of the late Mr. Carpenter, and worked out since his death by his coadjutor, Mr. Slater—there is more hope, as we learn from the description of it contained in the book under notice that the bishop has expressed his intention of erecting at least some portion of the structure. The description of the accompanying examples we give in Mr. Hope's own words.

"Inverness Cathedral still only exists in design. The last work of Carpenter, who was lost to art in 1855, was the preparation of a design for the west end of the cathedral proposed to be erected at Inverness for the Scottish diocese of Moray and Ross, which was completed just in time for the International French Exhibition of that year. After his death Mr. Slater was commissioned to draw a plan to suit that elevation, and embody what appeared to be its author's whole mind, and he accordingly produced one upon a large and stately type, to be carried out in the Middle Pointed. Although the size of the church—345 feet long by 170 at the transepts—prevents the hope of its being reared in our generation, the bishop for whom it was prepared expresses his intention to raise some portion of the building. In the meanwhile the conception has its value as the dignified idea of a modern cathedral suitable to the worship of our actual church.

Carpenter—a man who never had the worldly good fortune to complete a building equal to himself—had executed, while in more robust health, the entire set of designs for a cathedral which it was proposed to erect at Colombo, the capital of Ceylon. Out of this series, which was produced in 1847, I have selected not only the plan, but also the longitudinal elevation, and the longitudinal and transverse sections, alike for their intrinsic merit, and as memorials of their gifted architect. The church it will be seen is of ample dimensions; and while the style is modelled on English First Pointed, the requirements of the oppressive climate are met by the open external aisle or loggia which encircles the entire building, in addition to the ordinary internal aisle, and by the clerestory galleries in the double thickness of the walls, presenting internally almost the appearance of a triforium, while the spacious narthex or western vestibule, is suitable, according to early precedent, to a church planted in the midst of a vast heathen population, for practical no less than ecclesiastical reasons. It is greatly to be regretted that in the construction of the actual cathedral of Colombo this able project seems to have been entirely overlooked, for, although the cathedral institution exists in the capital of Ceylon, the building in which it is fixed is merely a modified reproduction of a commonplace parish church, carried out I fear under non-professional guidance.

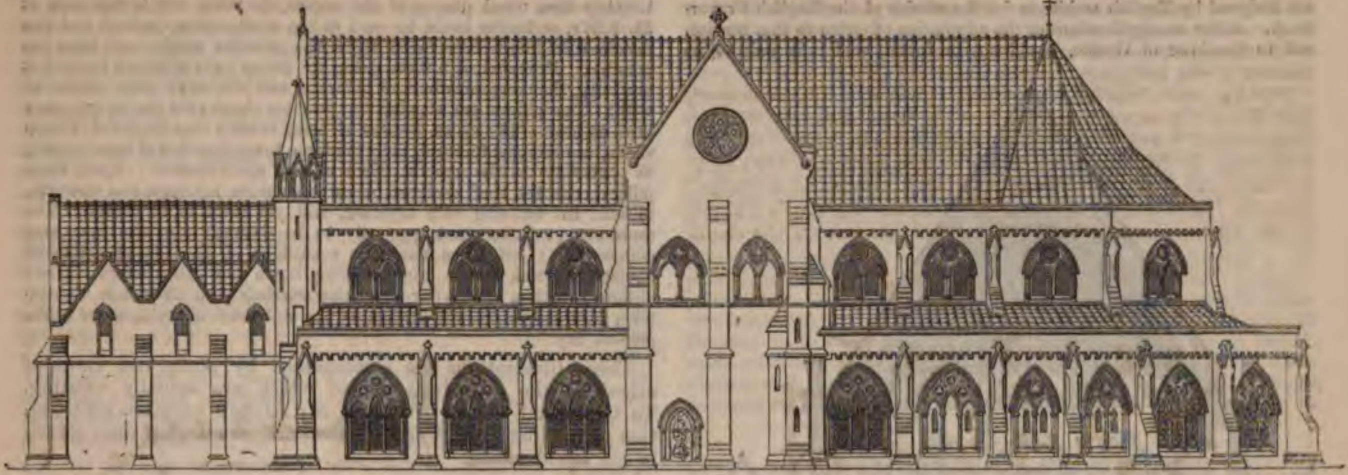


Plan of proposed Colombo Cathedral. 75 feet to inch.

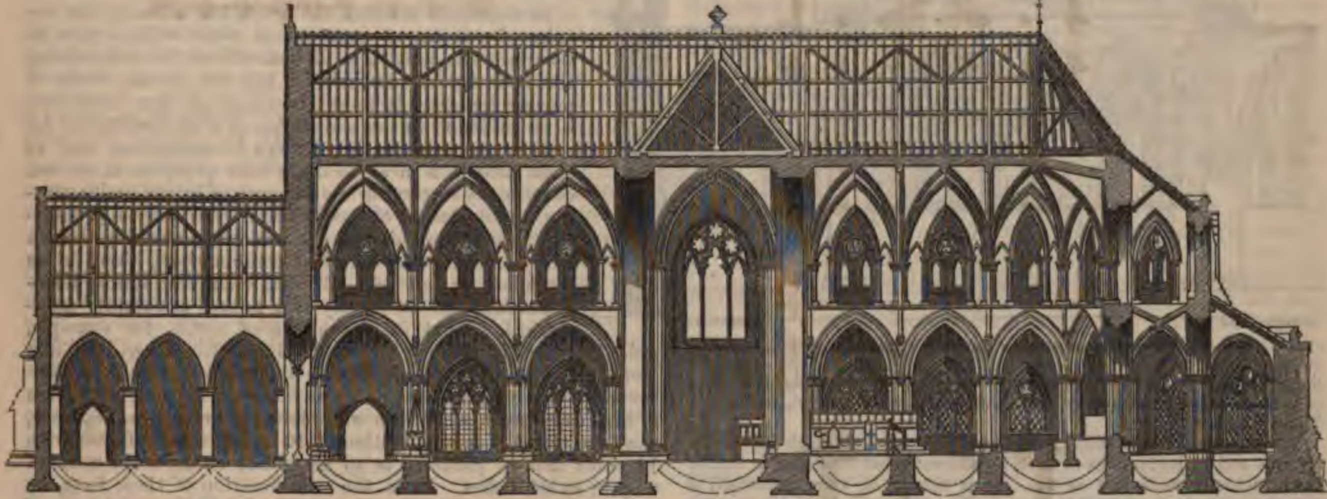


Transverse Section of proposed Colombo Cathedral.

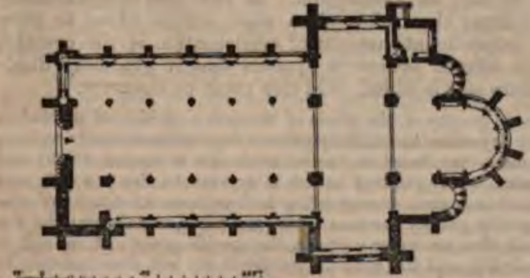
The lapse of thirteen years again brought round the completion of a series of plans for a cathedral on a stately scale, for the use of a newly-constituted colony to the north of New South Wales, where the conditions of a sultry climate had to be considered; and the Bishop of Brisbane sought his see provided with designs from the pencil of Mr. Burges. Brisbane, the capital of Queensland (the appropriate name for what used



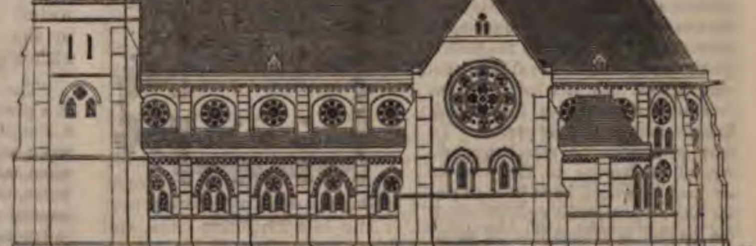
Exterior of proposed Colombo Cathedral.



Longitudinal Section of proposed Colombo Cathedral.

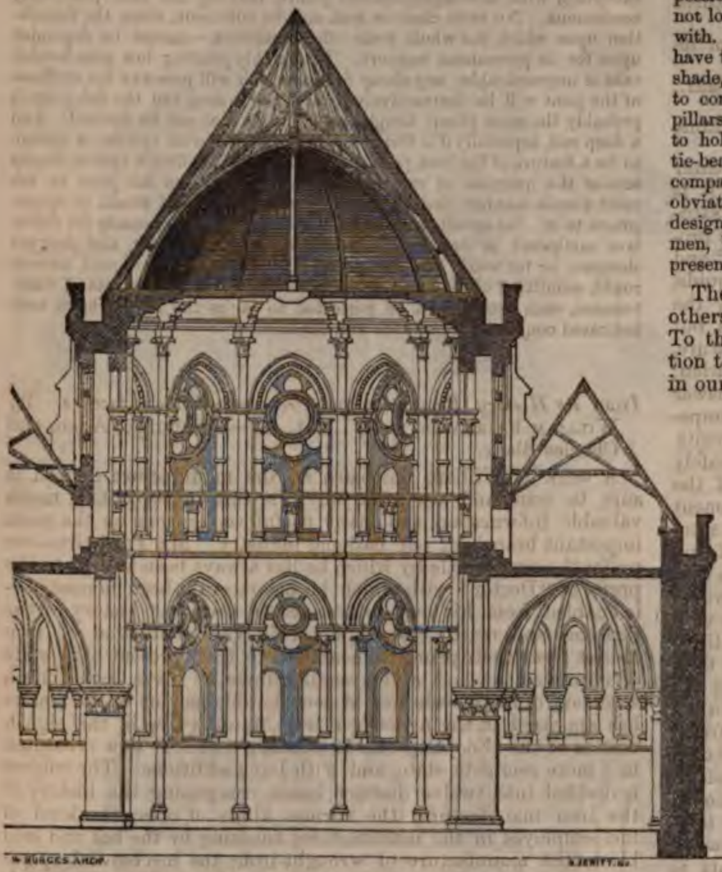


Plan of Brisbane Cathedral. 75 feet to inch.



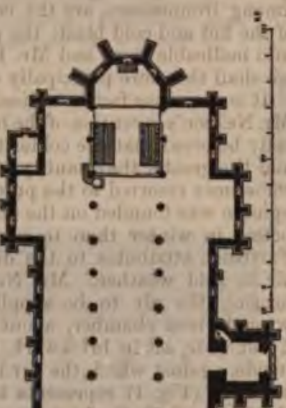
Exterior of Brisbane Cathedral.

to be termed Moreton Bay) is, to be sure, but a semi-tropical city compared with Colombo. Still, the heat there to English feelings is excessive, and demands precautions. Like Carpenter, Mr. Burges has sought his style in the earlier epoch of Gothic, though, faithful to his *penchant*, and to the now rather fashionable spirit which received so strong an impetus in that international competition for Lille Cathedral, in which Mr. Burges in concert with Mr. Clutton came off victorious, he has adopted the French form of First Pointed. I shall not renew the discussion upon the applicability of this style to our actual church architecture. Whatever may be its practical value as a general rule, the merit of Mr. Burges' special adaptation of it at Brisbane is incontestable; where its peculiar massiveness, which might render it less serviceable in England, has its own appropriate use. Carpenter, at Colombo, met the problem of cooling the air by veiling his abundant openings with external galleries, themselves pierced in respect to the internal windows, so as to combine the maximum of opening with the minimum of solar light. Mr. Burges, for his part, while to a certain extent he adopts that expedient in his ingenious combination of triforium and clerestory, yet bases his plan upon what has been called, by a self-explanatory term, the speluncar principle of tropical architecture. Hence his thick walls, which are so well suited to Early Pointed; his narrow windows, made to exclude rather than admit light; and hence the coved roof, a feature which we should hail in the Gothic of any climate. It would lead me too far away from my own subject if I were to attempt to balance the arguments, practical and scientific, with which the two systems of architecture for hot climates—the draught-admitting and the speluncar—are defended and impugned, for I am only concerned with these tropical cathedrals in so far as they are designed by English architects for the service of the English Prayer-Book. Abler exemplifications of the adaptation of either to that service, and to the laws of Gothic, could not be found; and it is only to be deeply regretted that the opportunity for building one of them (if even in part only) has passed away, and that the other has not yet, as far as I know, been set in hand.



TRANSVERSE SECTION OF BRISBANE CATHEDRAL.

The tropical church which I shall next produce, although inferior in its scale and its pretensions to those for Colombo and Brisbane, is, unlike them, actually built and in use. It is not, to be sure, technically a cathedral, but is the principal church of a community which possesses its own independent representative constitution, and its construction formed the subject of parliamentary solicitude and parliamentary munificence, so that it may very fairly take its place in the series. It is the church rebuilt from the designs of Mr. Slater, in the island of St. Kitt's, in the West Indies, after the destruction of a former one by an earthquake, and consecrated in 1859. The fear of the recurrence of the same calamity which had ruined its predecessor imported one fresh element into the architect's considerations. He had not only to provide for the admission of air, but to provide against the risk of a sudden overthrow by making his church flexible, and as it were elastic. To have attempted to stand against, instead of bowing to the possible concussion, would have been to undertake an enterprise against which the patent costliness was an argument as irrefragable as it was practical. Accordingly the speluncar theory was out of court in this instance, and the point which Mr. Slater aimed at was to make his building light and well ventilated, and yet sun-tight. The simple expedient of Middle Pointed windows with jalousies met the requirements of sun and air. The comparative thinness possible in this style pleaded in its favour as to the remaining requirement. Fortunately that usual plague of the tropics, the white ant, is unknown at St. Kitt's, so timber could be used in the construction; indeed, had this mischievous insect been found there the jalousies might have been impossible. Provided with these data, Mr. Slater gave a church broad but not lofty, the dangerous bulk of triforium and clerestory being dispensed with. The pillars are slender, but not too slender for the weight they have to bear. The aisles, instead of being thrown into the relief of deep shade, are brought forward, as in the large town churches of later Gothic, to contribute to the general effect of airy spaciousness. Upon these pillars rests the roof, designed so as to combine lightness and strength, to hold the building well together, and yet itself to be elastic. The tie-beams (a feature not generally to be desired) give the necessary compactness; while the moderate scantlings of the timber employed obviate the risk of the roof crushing down the substructure. Thus designed, with a reason for every characteristic, this church is a specimen, both successful and modest, of the ecclesiastical architecture of the present day."



PLAN OF ST. KITT'S CHURCH.
75 feet to inch.

These illustrations are accompanied by plans and views of others of the cathedrals named which are actually existing. To these and other portions of Mr. Hope's valuable contribution to the literature of ecclesiastical architecture we shall return in our next number.

The Engineer's Manual of the Hydrometer; with Rules, Worked Examples, and Complete Tables, applicable to Marine Boilers. By LIONEL SWIFT, R.N.—London: John Weale.

In this small manual Mr. Swift has collected the results of a series of experiments made with a view to ascertain the best form of hydrometer for determining the quantity of salt held in solution in the water of marine boilers. It might be supposed that there was little difficulty in the adaptation of that instrument for such a purpose; but Mr. Swift's investigations tend to show that it is next to impossible to arrive at correct conclusions respecting the strength of brines under varying circumstances of temperature by a scale of progressive displacements. He commences by showing that in many instances of chemical combinations, there is an attendant change of a physical character, totally unaccountable, and frequently of a nature apparently paradoxical. That in the alloys of metal, for example, gold increases in volume when combined with silver, lead, and iron; and that the alloy diminishes in bulk when gold is combined with zinc, tin, bismuth, or antimony. This concentration of bulk is so great when iron and platinum are melted together, that the result of a combination of 10 cubic inches of iron with 1¼ cubic inch of platinum is an alloy that occupies the space of only 9¾ cubic inches. From the consideration of these facts, he is led to remark on the fallacy of the celebrated experiment of Archimedes for determining the purity of the gold in the crown of Hiero by its specific gravity. Similar irregularities are found to exist in various mixtures of salt and water at different temperatures. We need scarcely say that the construction of the hydrometer is based on the principle that the weight of a floating body is equal to the quantity of liquid it displaces; therefore, as it is assumed that the density of water increases in proportion to the quantity of salt it contains in solution, the height at which the stem of the hydrometer floats is supposed to indicate the strength of the brine. Mr. Swift's experiments show the fallacy of such an assumption. In reference to the condensation of volume that takes place when salt is added to pure water, the proportionate amount of condensation is the greatest in the very diluted brines: it appears that it gradually diminishes as more salt is added. On this point he observes:

"The specific gravity of the whole of the saline portion of sea-water, in a perfectly dry state, and slightly pressed together sufficiently to form a compact mass, we found in varied trials not to exceed 2·000; and when saturated to its greatest extent it appears to rise to 2·850; and when saturated to a state corresponding to four times the density of sea-water, the specific gravity becomes 3·160; and when containing twice the amount of salt that sea-water contains, the specific gravity of the salt is increased to 3·476; and the specific gravity of the salt when existing in the proportions found in sea-water is further increased to 3·933; and again, when further diluted to a specific gravity of compound of 1·0042, the specific gravity of the salt becomes about 11·000, and still regarding it with the same view of change, the specific gravity of course would thus increase to an unassignable value when diluted to its greatest extent."

The influence of temperature on the volume and specific gravity of brines is much greater than on pure water. Brines are far more sensible of the additions of heat at low temperatures, and are comparatively not so much affected at high temperatures as fresh-water. A fully saturated brine expands $\frac{1}{19\cdot23}$ of its volume, by being heated from a temperature of 39° to 212° Fahr.; while fresh-water expands only $\frac{1}{28\cdot08}$ of its volume by the same addition of heat. The dilation of the latter is nine times greater for the 20° of temperature nearest its boiling point, than it is for the 20° nearest its maximum density, whilst a fully saturated brine expands between those temperatures only in the proportion of 1 to 1·34; and between the temperatures of 110° and 130° the ratio of expansion is about uniform for both liquids. Thus it will be seen, as Mr. Swift observes, that not only the ultimate amount of expansion of a volume of these brines, but the rate of expansion near the limits of change and temperature, is entirely dependent on the intermediate state of saturation; and we see how impossible it is for any hydrometer to answer for brines in different stages of saturation and at varying temperatures, unless corrected by the results of observed experiments. It appears therefore that no ordinary hydrometer can be safely relied upon for determining the degree of saturation of the water in marine boilers, and that it requires some instrument specially adjusted to the varying circumstances of heat and saturation; and yet, strangely enough, the naval hydrometer at present used by engineers in the royal navy is the same that is constructed for the excise officer to determine the strength of worts. Mr. Swift shows that the use of this instrument involves very considerable error, so that when the scale stands at 30 there is an excess of nearly 9 ounces of salt in a cubic foot more than the common mode of reading the indications would lead the engineer to suspect, and the error would go on increasing in the more saturated brines. The relative economy of using fresh-water or sea-water in a boiler is stated by Mr. Swift to be only ·75 per cent. in favour of fresh-water, not taking into consideration the loss from "blowing out." But the loss of fuel occasioned by the latter operation is stated to be so great, that the total percentage of loss from blowing out and using sea-water, when working at a pressure of 30 lb. per square inch, amounts to about 10·12. Tables showing the specific gravities of brines, and their dilations by heat at temperatures from 60° to 200°, and the corresponding temperature in using the naval hydrometer, are appended to the Manual for the purpose of correcting the indications of that anomalous instrument.

Rudimentary and Practical Instructions on the Science of Railway Construction.—London: John Weale.

This is one of Mr. Weale's valuable series of rudimentary publications, in which the science and art of constructing railways are explained and set forth very lucidly within a small compass, and illustrated with upwards of 150 woodcuts. Directions are given for land surveying, levelling, the laying-out of railways, tunnelling, and the construction of the permanent way in all its details. It is the second edition of the work written in 1850 by Sir Macdonald Stephenson, and in this new issue copious use is made of Mr. Holley's quarto volume, particularly in the division relating to the formation of the permanent way. The following concluding remarks on the construction of rails, and on the system of jointing them, deserve attention:—

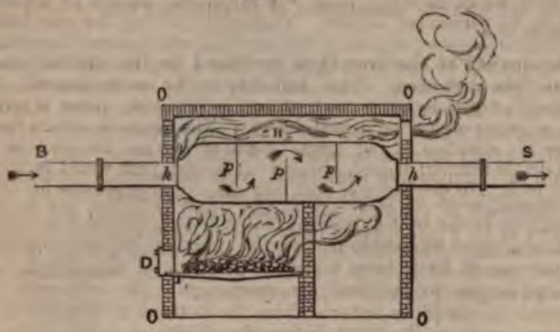
> "It is not the practice in England to roll the steel into the rail-pile, as has been done to some extent in the United States, without much success, since the hard material peels from the soft, for reasons already stated. It is probable however that puddled or semi steel, possessing so much of the nature of iron together with its steel qualities, can be rolled so firmly upon iron that it will not peel. By this process the cost of steel-headed rails may not be greater than that of iron rails, since less material will have equal strength and stiffness.
>
> The present movement as to rails turns chiefly on a better proportion of bar and a better quality of iron. It has been customary to waste 12 tons of iron per mile, worth £140, under the heads of our rails, for no other reason than that such inferior iron was used as to crumble down on the edge. All the iron put in rails should be worked to double the amount generally practised, and while the whole cost might be increased one-third, the wear of the iron would be fully doubled. Experience has proved this again and again. English roads are taking up this reform in earnest, and some are paying above twice as much for their iron as the current prices of ordinary bars. . . . .
>
> No track is complete, nor can it economically carry a heavy traffic, excepting with thoroughly spliced joints, making the rails practically continuous. No mere chair or seat can be sufficient, since the foundation upon which the whole rests—the earthwork—cannot be depended upon for its permanent support. Thoroughly jointing low pear-headed rails is impracticable; any cheap fixture which will preserve the stiffness of the joint will be destructively rigid. For a deep rail the fish-joint is probably the most cheap, simple, and durable that can be devised. And a deep rail, especially if it forms a part of the sandwich system, is certain to be a feature of the best permanent way. The sandwich system finally settles the question of rail-joints, by embodying the fish-joint in the most simple manner; indeed, nothing but the fish-joint would be appropriate to it. No excellence of joint fastenings can compensate for defective earthwork or drainage; bad ballast; small, irregular, and decayed sleepers; or for weak, unsound rails. Before we can have good, smooth roads, admitting of easy traction at high speeds with a low rate of maintenance, each detail must be perfected so far as the means have been indicated conjointly by science and experience."

Iron: its History, Properties, and Processes of Manufacture. By William Fairbairn, C.E., LL.D., &c.—Edinburgh: Adam and Charles Black.

A work by William Fairbairn on the manufacture of iron is sure to command attention, for it is certain to contain much valuable information and many useful suggestions on the most important branch of our national industry. Mr. Fairbairn—we prefer the simple title by which he has always been known, to the prefix of "Doctor" with which he has recently been honoured—is enabled from his own experience to trace the history of the furnaces and machinery employed in the production of iron almost from their primitive condition to their present high state of improvement, and in this small volume he gives the public a summary of his knowledge. A considerable portion of the matter has appeared in the article on Iron Manufacture in the eighth edition of the 'Encyclopædia Britannica,' but it is now presented in a more complete state, and with large additions. The subject is divided into twelve distinct heads, comprising the history of the iron manufacture; the various kinds of ores; the kind of fuel employed in the manufacture; smelting by the hot and cold blast; the manufacture of wrought-iron; the mechanical operations of the cast-iron manufacture; the forge; Mr. Bessemer's process; the manufacture of steel; the mechanical properties of cast and wrought iron and steel; the chemical constituents of iron in its manufactured states; and, finally, the statistics of the iron trade. It could not be expected that in a small book of 230 pages all these branches of the subject could be developed, and some of them are dismissed with very brief notice. The points of most interest, so far as they have a bearing on questions respecting which much difference of opinion exists among ironmasters, are the consideration of the relative merits of the hot and cold blast; the processes of the conversion of crude into malleable iron; and Mr. Bessemer's process: to which points we shall therefore principally direct attention.

It is a curious fact as noticed by Mr. Fairbairn, that previous to Mr. Neilson's invention of the hot-blast in 1828, practical men generally believed that the colder the blast the better was the quality and the greater the quantity of the iron produced, and ironmasters sometimes resorted to the practice of refrigerating the air. That opinion was founded on the observation that the furnaces worked better in winter than in summer,—a circumstance which Mr. Fairbairn attributes to the diminished amount of vapour in the air in cold weather. Mr. Neilson's earliest hot-blast oven for heating the air to be supplied to the furnace, consisted of a wrought-iron chamber, about 4½ feet long by 3 feet high and 2 feet wide, set in brickwork like a steam-boiler, with partitions inside, against which the air impinged in passing through. The woodcut (Fig. 1) represents this original contrivance, in which the letters O, O, O, show the oven in which the heating chamber H, was set, and *p*, *p*, *p*, are the partitions over and beneath which the air passed. By this means a moderate current of air was heated to 300° or 400° Fahr. Mr. Neilson afterwards introduced long ranges of tubes to increase the heating surface, by which means a temperature of 600° was first attained. By subsequent improvements in the ovens, many of which are described and figured, the blast for three tuyeres can be heated to 800°. The consumption of coal in these ovens varies from 9 cwt. to 5 cwt. per ton of iron produced.

Fig. 1.



Thé hot-blast process met with great opposition when first introduced. The invention was more than once on the point of being abandoned, and Mr. Neilson was obliged to transfer the greater portion of his interest in it to others, whose combined efforts and influence were necessary to insure its success. It has now however triumphed over its early difficulties, and is adopted at the greater number of ironworks in other parts of Europe as well as in Great Britain. Mr. Fairbairn speaks favourably of the hot-blast, not only economically, but as a means, if properly applied, of improving the quality of the iron. He observes—

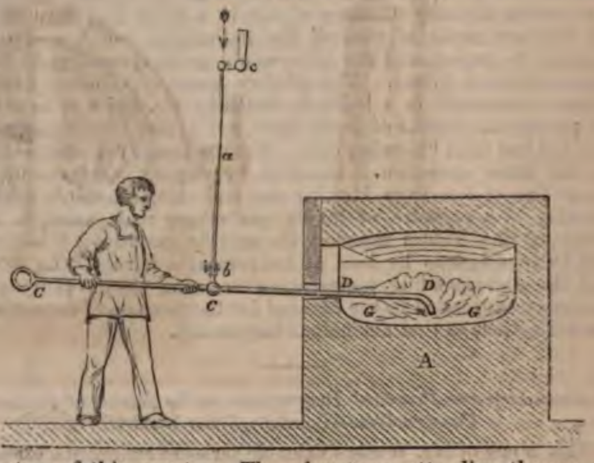
> "With regard to the advantages and defects of the hot-blast process much has been said on both sides, and the question does not appear by any means exactly settled. It is asserted on the one hand that iron reduced by the hot-blast loses much of its strength, whilst on the other it is contended that the quality of the iron is richer, more fluid, and better adapted for general purposes than that produced by the cold-blast. The advocates of the hot-blast say that the process has increased the production and diminished the consumption of coal three or four fold; and the upholders of the cold-blast maintain that the same effects may be produced to almost the same extent, by a judicious proportion of the shape and size of the interior of the furnace, a denser blast, and greater attention on the part of the superintendent to the process. On these points, it appears to us that although the hot-blast has enabled the manufacturer to smelt inferior ores, cinder heaps, and other improper materials, and to send into the market an inferior description of iron, this is no reason for its rejection, but rather an argument in its favour. It is true that when a strong rigid iron is required for such works as bridges or artillery, the somewhat uncertain character of hot-blast metal renders it objectionable, but this appears to be due rather to carelessness or want of attention in the manufacture, than to the use of heated air or defects in the process. On the other hand, the hot-blast, by maintaining a higher temperature in the furnace, insures more effectually the combination of the carbon with the iron, and produces a fluid metal of good working qualities, generally superior to cold-blast iron in cases where great strength is not required; and moreover we have yet to learn why even the strongest and most rigid iron cannot be made by this process. The comparative strength of hot and cold blast iron will however be given in another part of this treatise; for the present it is sufficient to observe that the results of the experiments are not unfavourable to the hot-blast iron, either as regards its resistance to a transverse strain, or its power to resist impact."

The utilisation of the waste gases of blast furnaces, which has been successfully adopted on the Continent, is but very little practised in this country, where the abundance of fuel makes the ironmaster indifferent about saving the heat that escapes. In South Wales the plan has been adopted advantageously to some extent, but the closing of the top of the furnace to confine the gases is found to produce white iron; on which account the process has been often abandoned. We have seen it used successfully in the ironworks near Swansea, where the gases from the furnace are applied to heat steam boilers, and Mr. Fairbairn notices this method of economising fuel very favourably.

The conversion of crude iron into malleable iron is effected by separating in a gaseous state the carbon contained in the iron, by combining it with oxygen, whilst the other foreign matters combined with the iron pass into the slag. The several processes to which the iron is subjected to deprive it of carbon are—first to heat it in a refining furnace, and afterwards in a reverberating furnace, where the fuel and metal are kept apart by a bridge, and the combination of the carbon with oxygen is facilitated by puddling or agitating the surface of the melted mass. The refining process may however be dispensed with, and methods have been recently introduced for facilitating the combination of the carbon with oxygen by the introduction of steam. When all the carbon has to be expelled in one furnace, the generation of gas is much more energetic, and as the fluid iron is greatly agitated by the bubbles of gas, the operation has been called the "boiling process." The use of steam in the "boiling" was patented by Mr. James Nasmyth in 1854, and it has been very successful in those puddling furnaces in which it has been adopted. The steam is introduced at about 5 lb. pressure to the square inch, as soon as the metal is fused. The oxygen of the steam having a greater affinity for the carbon at that high temperature than for hydrogen or iron, the carbon is rapidly converted into carbonic acid or carbonic oxide, and escapes in a gaseous form. The liberated hydrogen of the steam unites with sulphur, phosphorus, or other substances contained in the iron or fuel, which, if they remain, have a very prejudicial effect on the quality of the iron. The mode of operating by Mr. Nasmyth's process is shown in the diagram (see Fig. 2). The steam from the boiler descends through the vertical jointed pipe *a*, and is conducted into the furnace through the tube or rabble D D, which is bent at the end so as to inject the steam on the liquid metal GG. This tube is introduced into the furnace immediately the iron is melted, and the workman moves it slowly about in the molten metal; the mass begins to thicken in about five or eight minutes, when the steam tube is withdrawn, and the operation is finished in the ordinary way with the common "rabble." There is a great saving of time by this method, during the hottest and most laborious part of the operation, and the iron is said to be more effectually purified, and with greater economy, than by the processes previously in use.

A mode of puddling iron by gas is in extensive use on the Continent, in what is called the Silesian Gas Furnace, which Mr. Fairbairn earnestly recommends to the attention of the ironmasters of this country. The advantages attending the use of gas instead of other kinds of fuel are stated to be the entire absence of smoke in consequence of complete combustion, the saving of 33 per cent. in fuel, the absolute control the attendant has over the furnace, the simplicity with which it can be worked, and the absence of ash or other impurities.

Fig. 2.



A considerable portion of Mr. Fairbairn's book is devoted to a description of Mr. Bessemer's process, of which he entertains a very favourable opinion, especially with the recent improvements that have been added to it, and of which Mr. Bessemer has furnished an account. When this ingenious plan of refining crude iron—by making the carbon to be removed serve as fuel for its own combustion—was first announced, it took the world by surprise, and exalted expectations were raised of the advantages to be derived from this self-acting method of purification. There were however many practical difficulties to be overcome, which tended to throw a damp on the hopes of the inventor and his friends, but he has nevertheless continued his endeavours to bring the process to perfection; and in its present state it bids fair to realise the original expectations. Mr. Bessemer's furnaces are made of boiler-plate lined with fire-brick or loam, and they are so contrived, that the instant the molten crude iron is run into them from the blast furnace jets of air are forced in, the oxygen of which immediately combines with the carbon in the iron and produces vivid combustion. The effect is thus described:—

"A rapid boiling up of the metal was heard going on within the vessel, the iron being tossed violently about and dashed from side to side, shaking the vessel by the force with which it moved. Flame, accompanied by a few bright sparks, immediately issued from the throat of the converting vessel. This state of things lasted for about fifteen or twenty minutes, during which time the oxygen in the atmospheric air combined with the carbon contained in the iron, producing carbonic acid gas, and at the same time evolving a powerful heat. Now as this heat is generated in the interior of, and is diffused in innumerable fiery bubbles throughout the whole fluid mass, the vessel absorbs the greater part of it, and its temperature becomes immensely increased; and by the expiration of the fifteen or twenty minutes before named, that part of the carbon which appears mechanically mixed and diffused through the crude iron has been entirely consumed. The temperature however is so high that the chemically combined carbon now begins to separate from the metal, as is at once indicated by an immense increase in the volume of flame rushing out of the throat of the vessel. The metal in the vessel now rises several inches above its natural level, and a light frothy slag make its appearance, and is thrown out in large foam-like masses. This violent eruption of cinder generally lasts about five or six minutes, when all further appearance of it ceases, a steady and powerful flame replacing the shower of sparks and cinders which always accompanies the boil. The rapid union of carbon and oxygen which thus takes place adds still further to the temperature of the metal, while the diminished quantity of carbon present allows a part of the oxygen to combine with the iron, which undergoes a combustion, and is converted into an oxide. At the excessive temperature that the metal has now acquired, the oxide as soon as formed undergoes fusion, and forms a powerful solvent of those earthy bases that are associated with the iron. The violent ebullition that is going on mixes most intimately the scoriæ and metal, every part of which is thus brought into contact with the fluid oxide, which will thus wash and cleanse the metal most thoroughly from the silica and other earthy bases which are combined with the crude iron; while the sulphur and other volatile ma'ters, which cling so tenaciously to iron at ordinary temperatures, are driven off, the sulphur combining with the oxygen, and forming sulphurous acid gas. The loss in weight of crude iron during its conversion into an ingot of malleable iron was found, on a mean of four experiments, to be 12½ per cent., to which will have to be added the loss of metal in the finishing-rolls. This will make the entire loss probably not less than 18 per cent. instead of about 28 per cent., which is the loss on the present system. A large portion of this metal is however recoverable by treating with carbonaceous gases the rich oxides thrown out of the furnace during the boil. These slags are found to contain innumerable small grains of metallic iron, which are mechanically held in suspension in the slags, and may be easily recovered. It has already been stated that after the boil has taken place, a steady and powerful flame succeeds, which continues without any change for about ten minutes, when it rapidly falls off. As soon as this diminution of flame is apparent, the workman knows that the process is completed, and that the crude iron has been converted into pure malleable iron, which he will form into ingots of any suitable size and shape, by simply opening the tap-hole of the converting vessel, and allowing the fluid malleable iron to flow into the iron ingot-moulds placed there to receive it. The masses of iron thus formed will be perfectly free from any admixture of cinder oxide, or other extraneous matters, and will be far more pure, and in a forwarder state of manufacture, than a pile formed of ordinary puddle-bars. And thus by a single process, requiring no manipulation or particular skill, and with only one workman, from three to five tons of crude iron pass into the condition of several piles of malleable iron, in from thirty to thirty-five minutes, with the expenditure of about one-third part of the blast now used in a finery furnace with an equal charge of iron, and with the consumption of no other fuel than is contained in the crude iron."

The quality of the iron thus produced in the earlier experiments was defective. The difficulty to be overcome was the removal of the sulphur and phosphorus which most cast-iron contains, and which neither the high temperature nor the copious supplies of air seemed to effect. Steam, hydrogen, and silicates of iron and manganese were tried, with but partial success; and the employment of crude iron as free as possible from those impurities is the best expedient hitherto ascertained for the production of good malleable iron by this process. Several important improvements have been made in the form of the furnace, and the appliances to facilitate its operations. As originally constructed the air-pipes entered from the bottom, so that it was necessary to put on the blast before the charge of molten iron was introduced. The annexed diagrams show the form of the apparatus as at present constructed, in elevation and in section. The furnace is made of a globular form, and is supported on trunnions, and on one of them carries a pulley-wheel B, round which a wire rope passes attached to a hydraulic lift. The blast is brought downwards from the top by a single tuyere D, and may be raised or lowered as required by a small hydraulic crane E. The blast-pipe G, rises perpendicularly from the floor level. The tuyere is composed of circular bricks having a central hole, through which an iron rod passes, by means of which the tuyere is held firmly together. The molten metal is poured from the globular vessel into the casting ladle by turning it partly on the trunnions, so as to lower the mouth. When the process is finished the casting ladle is attached to the arm of an hydraulic crane, and is so arranged that it swings round over the ingot-moulds, placed in a circle, and the metal runs out from a hole in the bottom of the ladle, that is stopped by a conical valve when each ingot is filled. The globular vessel or furnace is 7 feet in external diameter.

Fig. 3.

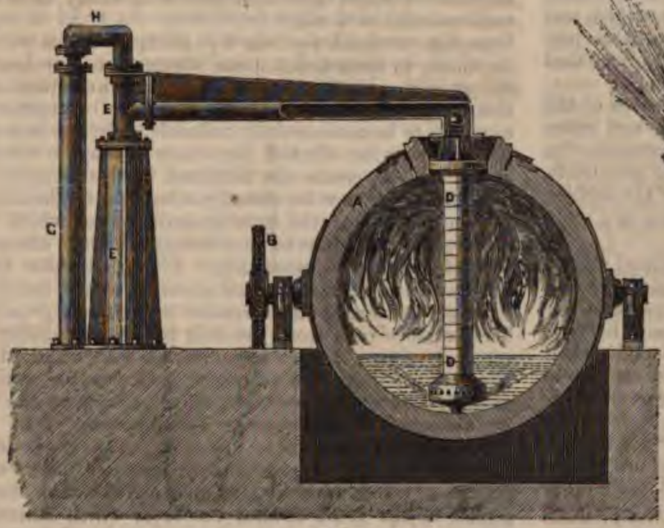
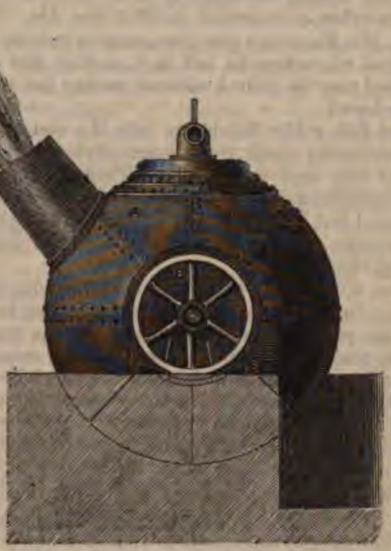


Fig. 4.



One part of Mr. Bessemer's process, to which Mr. Fairbairn attaches much importance, is the facility it affords for the production of what is called *semi-steel*.

"At the stage of the process immediately following the boil, the whole of the crude iron has passed into the condition of cast-steel of ordinary quality. By the continuation of the process the steel so produced gradually loses its small remaining portion of carbon, and passes successively from hard to soft steel, and from softened steel to steely iron, and eventually to very soft iron; hence at a certain period of the process any quality may be obtained: there is one in particular, which by way of distinction he calls semi-steel, being in hardness about midway between ordinary cast-steel and soft malleable iron. This metal possesses the advantage of much greater tensile strength than soft iron; it is also more elastic, and does not readily take a permanent set, while it is much harder, and is not worn or indented so easily as soft iron; at the same time it is not so brittle or hard to work as ordinary cast-steel. These qualities render it eminently well adapted to purposes where lightness and strength are specially required, or where there is much wear, as in the case of railway bars, which, from their softness and lamellar texture soon become destroyed. The cost of semi-steel will be a fraction less than iron, because the loss of metal that takes place by oxidation in the converting vessel is about 2¼ per cent. less than it is with iron; but as it is a little more difficult to roll its cost per ton may fairly be considered to be the same as iron. As its tensile strength is some 30 or 40 per cent. greater than bar-iron, it follows that for most purposes a much less weight of metal may be used, so that taken in that way the semi-steel will form a much cheaper metal than any we are at present acquainted with."

The conversion of crude cast-iron into steel and malleable soft iron, by expelling different quantities of carbon, suggests the idea of producing steel by arresting the process when sufficient of the carbon has been driven off to render the remaining mass steel. When in the state of cast-iron the metal contains 4 per cent. of carbon, has a tensile strength of 18,000 lb. per square inch, and is worth £3 per ton. When entirely deprived of carbon it becomes malleable iron, it has a tensile strength of 56,000 lb. per square inch, and its value is £8 per ton; but if 1 per cent. of the original carbon be allowed to remain, the iron becomes converted into steel, the tensile strength is then 130,000 lb. per square inch, and its value is increased to £50 per ton. The question then occurs, Mr. Fairbairn observes, cannot iron be purified, and this 1 per cent. of carbon be left in it, so that the valuable properties of steel may be gained without raising the cost above that of malleable iron?

We cannot follow Mr. Fairbairn into the consideration of the modes of producing steel, the comparative strength and other properties of iron and steel under different circumstances, the chemical composition of iron, and the statistics of the iron trade. There is indeed but little novelty in these branches of the subject, and the statistics of the trade are not brought down to a more recent period than 1857.

There is an appendix to the volume, on "armour-plated ships," in which Mr. Fairbairn, as the father of iron shipbuilding, naturally takes the part of iron against wood, for the purposes of war as well as for the commercial marine. "In my opinion," he says, "the whole navy of Great Britain must be remodelled, and rebuilt of iron; and no administration in this country should venture to put another wooden vessel on the stocks." After expressing his belief that ships of war should be made entirely bomb-proof, and invulnerable to the heaviest shot, he alludes to "a new and important branch of manufacture," consisting in the production of wrought-iron in very large masses, which in all probability will shortly be established. This subject, Mr. Fairbairn states, is now under consideration by a committee, and though he mentions it somewhat mysteriously, we believe it is nothing more than the plan recently recommended by Mr. Samuda, at a meeting of the United Service Institution, of constructing the sides of invulnerable ships with iron of the required thickness to be shot-proof, instead of adding the armour-plates subsequently.

We cannot conclude our notice of this volume on iron and its manufactures without strongly recommending it as a valuable summary of practical knowledge on that important branch of manufacture.

A Practical Treatise on Coal, Petroleum, and other Distilled Oils.
By Abraham Gesner.—New York: Baillière Brothers.

The introduction of mineral oils for illumination and other purposes renders a book of this description very welcome to the practical chemist, the more so as the art of the proper development of oils from coal and other bituminous substances is comparatively of a recent date. The author claims to have been the first who succeeded, in America, in the manufacture of these oils, he having used it for lighting the rooms in which he held his public lectures, at Prince Edward's Island and other places, so long as fifteen years since. The book, which treats the subject in all its variety, is of a purely practical character. The author after recording the history of the progress of the distillation of mineral oils, and making mention of the introduction of the so-called *Kerosene*, and the manufacture of other bituminous oils which formed the subject of patents either in England or abroad, describes the effect produced on coal when exposed to the influence of heat. It is known that all organic bodies when so exposed, with free admission of the air, undergo combustion. Very different however are the changes produced in the combination of the various ingredients constituting such bodies when exposed to heat in a close vessel. This interchange of the elements then is effected by placing the coal in suitable retorts, in which, by the action of the heat, the bituminous and gaseous ingredients are freed from the other parts of the coal. The gases and vapours thus produced are next led into a condensing apparatus. The object of this condenser is to cool these gaseous and vaporous substances, so that they assume the liquid form where such is possible. It should therefore be of the first importance that the surface of the condenser be as extensive as possible, it being quite immaterial whether it be formed of one long pipe or of a series of pipes, laid either spirally or otherwise in water, which is maintained at the required temperature by the admission of cold water. The oils which are in this manner separated are of different specific gravities, of which the lightest—which have the character of a spirit rather than of an oil—are first distilled. When the heat amounts to about 800° Fahr., a number of pyrogenous substances are given out, known under the name of *dead oil*. The oils and vapours condensed are collected in the receiver, consisting of a series of tanks, which are usually placed underground, so as to admit of the descent of the products. Those gases which have not been condensed are either led into a special gasometer, or allowed to escape into the atmosphere. The oils which have been thus obtained are in a very crude state, and are intermixed in a great measure with water, ammoniacal liquid, carbonaceous and other impurities. In order to separate these from the crude oil the whole is pumped into a second receiver, in which, by means of a spiral steam-pipe, it is heated to about 90° or 100°. By this process the ammoniacal and other impurities are precipitated; and if the ammonia be present in sufficiens quantity to be commercially valuable, a further separation of thit product may be effected, by which it may be turned to useful account. The crude oils obtained in this manner, thus briefly described, may now be directly submitted to chemical treatment, but on account of the great quantity of tar which they contain require generally first to be distilled, which is effected in an iron still of ordinary construction. The distillation may be done either with or without the aid of steam. It is however preferred to employ steam, as the operation is by its use greatly facilitated. The vapours pass from the still into a condensing worm, composed of tubes, which are surrounded by water of about 100°. This water, if it were of a low temperature, would cause the solidification of the paraffine, which, filling up the worm, might be attended with dangerous consequences. Oils are distilled once, twice, or more times, according to the purity desired to be obtained. In addition to an explicit description of the manufacture of bituminous oils, the author directs the attention of the reader to the great natural resources which America possesses with respect to these oils; and concludes by giving a full account of the chemical products yielded by their distillation. The book contains many woodcuts clearly illustrating the subject, and may be recommended to all engaged in chemical pursuits.

THE ARCHITECTURE OF LONDON.[*]

By A. J. B. Beresford Hope.

When I talk of Architecture in London, I do not mean to convert myself into an architectural reviewer, and go about from building to building, criticising them as an art-critic would criticise pictures on these walls. What I propose to do is to take up London as a whole—a great existing whole; and doing so, taking London past, London present, and London in the future, deduce from this whole panorama certain teaching for the future, building that teaching on its actual condition, physical as well as architectural. In short, I want to stir you up to become volunteers to improve London in the way that I believe London might now be improved.

What is London? London is an ancient city—it is a northern city—it is a picturesque city. That London is an ancient city hardly requires proof: from Tacitus downwards there are numerous indications of its growing greatness and grandeur. That London is a northern city hardly requires demonstration either—particularly to those who had the fortune, good or bad, to be out in the recent snowstorm. I do not speak of London as a northern city in any contemptuous sense. The people of England are all Northerns in descent, in language, and in constitution,—Northerns in every relation of life, Northerns in everything that makes either individuals or nations historical and great. Let us not then be ashamed of being Northerns. Let us live up to the condition of life in which Providence has placed us, and let us not think that the being Northerns is any great damage or misfortune. A great deal has been said about Southern cities and their delightful climate; but on this point I may mention, that last summer, when travelling on the railway between Milan and Como, I met a very intelligent officer of the Italian army, who said, "Ah, we Italians are becoming very tired of our sun." Charles II., who never said a foolish thing, observed that England had a climate in which a man could take exercise on every day in the year.

---

[*] Lecture delivered at the Architectural Exhibition.

Granting, then, that London is an ancient and a northern city, I have also stated that it is a picturesque city. It is a picturesque, not a monumental city. It might be said, "Why is it not a monumental city? There is St. Paul's, Westminster Abbey, the Tower—not to speak of the Monument on Fish-street-hill." Here is the great difficulty in lecturing on a scientific subject such as architecture, in which the lecturer has to invent his own terms of art. No term of art comprehended in a single word can be so explicit, so concise, and at the same time so comprehensive, as to cover the whole ground for itself, and to exclude something else from trespassing on its own domain. For instance, in contrasting a monumental with a picturesque town, I may be met by the inquiry, "Why should not a picturesque building or town be monumental, and why should not a monumental town be picturesque?" There is really no answer to this question; but for the convenience of technical art—in short, to label the different divisions of the subject—it is necessary to rely upon incomplete, lame, and paltry definitions. The incomplete, lame, and paltry distinction which I draw between a monumental and a picturesque city is this: A monumental city is a city which has been, as it were, thrown out by one effort of the intellect of its builder, just as one monument or one building is thrown out by one intellectual effort of its architect. A picturesque city is one that has grown up under the different operations of many intellects; which might have more or less of unity in its general conception, but is not one vigorous shoot from the ground, sent up by the one inventor, but, as the name implied, a series of pictures, each picture differing from the one previously examined. Like Peter Naas's churches, differing each from the other; like Canaletti's pictures of Venice, differing each from the other: so Flemish churches, by the testimony of Peter Naas, are picturesque; and the streets of Venice, by the testimony of Canaletti, are picturesque also.

London, then, has grown up, in the course of revolving centuries, to be a picturesque city; and it is also, as I have said, a northern and an ancient city. Suppose you had to do with a city which was neither of these three. Suppose our accomplished chairman were called upon to design the federal capital of Australia, for example—what would he do? He would have to build a modern city, a southern city; not merely southern in respect to its being situated in the southern hemisphere, but southern because of the climate, which is much hotter than ours. How would he build this city—how construct a town in a vast unoccupied plain—

> "Where fancy sees
> Squares in morasses, obelisks in trees?"

He would do it in this way. He would give sweeps of buildings, or else each separate building standing in its own garden. He would also give broad straight streets. But neither Mr. Scott nor any architect of eminence would, in building a new city, fall back on that most clumsy, vulgar, and odious plan, of designing towns with streets running at right angles to each other—a plan which unites the maximum of ugliness with the maximum of inconvenience. Streets built at right angles are destitute of perspective; the only view to be obtained is from one end of the town out to the other end: whilst it is obvious that with streets at right angles there can be no short cuts from one point to another. Anyone building a new city would follow the new plan, adopted in Washington, of building the town radiating from various centres, the different rays crossing each other. By this plan the shortest cuts consistent with straight streets would be obtained. At the centre of every star, some large building would be placed, so that the spectator would see a public building before him at the end of every street; and at the various squares made by the intersection of the different rays, there would be a group of several large buildings to be seen. This would be a monumental city,—its streets straight, its buildings well placed, one or two being at every crossing, and the streets so broad that even omnibus tramways could run along them without the slightest inconvenience. Could this be done in London? I believe not. Ought we to repent of not being able to do this in London? I believe not. We ought not to dream of building a new city of prospective eminence, of speculative magnificence. We have another task before us, more sure, equally grand, equally worthy of the whole soul and thought of everyone who has the broadness of heart to deal with architecture not as a makeshift but as a science. We have by our individual exertions—small though they may be on the part of each of us, but great in the aggregate—to conduce to the convenience, the healthfulness, and the beauty of our great capital. Louis Napoleon has riddled Paris with broad boulevards. He may have done a great deal of good, and made great streets. No doubt he has. He may have swept away ruthlessly many most picturesque vestiges of old Paris. No doubt he has: but we could do neither the one nor the other; and we must accept our position. It is a position inherent in a free constitution—a nation in which the maximum of order combines with the maximum of independence. If we like to take France with the accidents and positions of France, let us take it. I for one am satisfied with the British constitution, and with London as it is. In 1666, indeed, we lost the opportunity of building a monumental London. Sir Christopher Wren made a very grand plan on the radiating principle, for rebuilding the city of London. That plan went to pieces, and came to nothing; but whether or not the city of London, rebuilt by Wren, would be mediocre as regards street architecture, or whether it would not have hampered us now, is a question into which I cannot enter. I fully admit the theoretic beauty of Wren's London; but it is a matter of history, and no more affects us practically than the question of what would have been the result if Harold had conquered William at the Battle of Hastings. London has been rebuilt, with all its old inconveniences and old picturesqueness, in the style of Charles II., and all the rest of the town has grown up at haphazard around it.

The question is, can we do any great heroic work to reconstruct and regenerate the map of London? Great work has been done in our century, within the last fifty years. Regent's-park, with all its faults, is a great work. Regent-street, ugly as are the buildings at either side of it, is a great artery. Cannon-street also is a great artery; and there are two main thoroughfares of recent construction, one to the north of Snow-hill, and the other near Westminster Abbey, both of which I regret to say bear the name of our gracious Sovereign. Then there is Victoria-park, at Hackney—a pretty thing perhaps, though not a great work of art. A new bridge is also about to be thrown across the Thames. When all these things are done, is there much more of the great and heroic kind to be carried out? A future generation may accomplish much, but I doubt if more can be done in our day except that one great, necessary, and noble work which has been the dream of so many years, and has now become an imperative reality—the quaying of the Thames. An old friend of mine, lately deceased, Sir Frederick Trench, who died in his eightieth year, and whose sterling simplicity of character must have been appreciated by everyone who knew him, was the real author of this Thames scheme. People laughed at him as a visionary, or repudiated him as an intruder. He published book after book, upwards of thirty years ago, advocating this scheme. He has not lived to see the realisation of his day-dream, but he was really the man to whom, in our generation, we owe this great improvement. I remember reading a debate on this subject, which took place in the House of Commons in 1825—thirty-six years ago. Great ministers and officials took part in that debate. Sir Robert Peel thought the thing would never do. Why? Because the Thames scheme would diminish the value of property in Essex-street, Arundel-street, and other streets in the same neighbourhood! He was not the only minister who raised difficulties about it; there was another member of Parliament, who in 1825 was a veteran member, having then been some twenty years in the House, and having held high office some eighteen or twenty years. He also made difficulties about that scheme. That veteran official was one of whom we have all heard by the name of Viscount Palmerston. He also in 1825, saw difficulties about the Thames scheme, as in 1859 he saw difficulties about the Foreign Office. When he was sceptical as to any great scheme for the regeneration of London being carried out, he made a sacrifice of much private feeling.

I advocate, and still adhere to the belief, that the greatest improvement in London would be the construction of a river-side park between Westminster Abbey and Charing-cross. Whilst we have the great forest tract of Kensington-gardens and Hyde-park—whilst we have the meadow of the Green-park—and the ornamental garden of St. James's-park coming within two or three hundred yards of the river, it is a shame and a disgrace that this great sweep of country in the middle of the town should not come down to its natural basis—the Thames. There are many other schemes which a fervid imagination might dream of. Sweeping away—not without a sigh—St. James's Palace, opening St. James's-street to the park, and then carrying it forward until it touched and was lost in the Regent's-park, would be a magnificent improvement. But putting all these considerations aside, the practical question is, how to improve London as it stands. London is admirably suited by its undulating character to conduce to a picturesque effect in its buildings. There is hardly any town of the size of London that lies in a country of so high an average elevation. Venice and Amsterdam, respectively perhaps the most picturesque southern and northern cities in the world, are each of them situate in morasses won from the sea. To be sure, the presence of water up and down the streets of those towns, and the character of the buildings that fringe the quays, give to Venice and Amsterdam their peculiar character; but compared to those cities, London is a series of broken hills, in fact, almost a mountainous country.

The cause of this vast size of London is nothing to be proud of. London might have had all its population, all its healthfulness, and a great deal more, and much more convenience than it has at present, but for the accidental fact of the building of this city having got from the hands of proprietors into those of middle-men, and from their hands into those of double-middle-men under them. The system of giving leases, advantageous as it may be in many cases, produces a spirit of speculation, and the various proprietors of farms about London throw them into the market, and endeavour to realise in their lifetime by parting with them on building leases. The principle is adopted of erecting buildings which cover the maximum of ground area with the minimum of vertical height; and so London has grown up with a combination of different proprietors, and different building leases under those proprietors, until it has reached that painful superfluity of area compared with its population which I hope will enable us to increase London, not into Essex or Hertford north and south, but upwards into the sky—into buildings more aërial, more bright, and more elevated. London being a Northern city, of course depends much on atmospheric effects. Those Southern suns give a clear sky, a climate which, excepting when a thunderstorm comes on, is of almost unbroken brilliancy; but there are none of those half shades, those mists that come and go, that play and variety of atmosphere which represent the same building under different aspects at different times. Those atmospheric effects are what the Northern architect should rely on. He must not rely too much on combining foliage with house building. Foliage does very well in climates where not much coal is burned, where consequently there is no deleterious atmosphere, and where the warmth of the sun keeps evergreens verdant, and brings out the deciduous trees early in spring. In London the combined effect of coal smoke and a colder climate causes the trees to come out very late, and to turn black very early. Common-sense has taught Englishmen that the best way to deal with foliage is to mass it together, to bring as it were large tracts of country inside the town, and mass the foliage with broad belts of turf between them. Our parks illustrate that principle, as do also our principal squares, such as Grosvenor-square, Lincoln's-inn-fields, &c. In a warmer climate the planting of trees in streets may be adopted, and it may be advantageous here also, though it is not to be relied on. In Amsterdam, for instance, there are rows of trees along the streets, which in summer conduce much to the picturesqueness of the city; but even in winter the gables compensate for the absence of foliage.

Any great scheme of reconstruction is not to be thought of: the widening of streets and the making of short cuts whenever that can be effected, are what we should rely on. A great deal may be done by broad pathways being, as it were, swept out by a cannon-ball; and the various means to that end—though in themselves they may seem insignificant—will produce a satisfactory result. To come to the point, what are to be the main principles of the future architecture of London? Design is one: material is another. I contend that under the head of design we may come to two main principles, each of considerable importance. The first is to play with the sky-line; to take that sky-line and deal with it boldly as the most important feature of the whole building. The second is to construct every house as in itself a unit, standing by itself, looking of course more to its height than to its width. The principle of building houses in terraces, which is the principle that must be adopted in a monumental city, and the principle so often adopted in London, can never be satisfactory. Do what we will, there is something about it that betrays the sham. In building a town, even if it were necessary to make a street as straight as an arrow, it would be better to break up and destroy the uniformity of the terrace. The idea of causing it to resemble a palace front can never be realised; and if the builder has to make one house higher than others it would be better to place it at the corner instead of in the centre of the mass. The sky-line resolves itself into three special forms—namely, the pyramid, the tower, and the cupola. By the pyramid I mean everything that tapers up with two lines meeting at a central point: it includes the spire, the cone, and the gable. By the tower I mean everything that rises in a square mass, and thus the tower includes the massive chimney-stack. By the cupola I mean everything that rises with lines more or less curvilinear, and under that term I include the Mansard roof. These three include everything out of which the sky-line ought to be formed; and in building in London, with its varied atmospheric effects, the sky-line ought always to be taken into consideration. An architect, if he has the selection, will choose the corner of two places for the erection of his building, on account of the opportunity it gives him for rounding off, which adds so much to the general effect. That is a very laudable ambition, because he will have scope there which he will fail to find elsewhere.

Dealing then with houses as units, what are we to come to? The first thing to look to is the elevation of the front, which is all-in-all. It is often very seductive to draw a very pretty geometrical elevation; but you may take my word for it, that is very often little better than a mockery, a delusion, and a snare, when building in a town. Every building has a front, but it has also two sides and a back; and the elevation of the front with respect to the two sides and back, will as often lead astray as lead in the right direction. Look to what London is—blocks of houses inclosing hollow squares within. These blocks cannot be called absolutely square, as they are generally longer in front than deep behind. If buildings are erected nearly on the same elevation, I will not say you will see an ugly back, because that would be hidden, but a side that in no way corresponds with the front, and you will also see an ugly cornice stopping 4½ inches round the corner. These cornices are the greatest temptations that can come in a frail and erring architect's way. You should avoid cornices as you would avoid any other form of evil. If you can carry it round, you should do so; but if you put a great lump of a cornice, hanging in front and ending in nothing, you will make a great sham, and expose yourself to the criticism you richly deserve from those who will look more than an inch round the corner. You should deal with the sky-line as I have stated, run the building up into a cupola, tower, or pyramid, and then you will place the cornice in its right position. I do not mean to say that the cornice should not play its part, but its part should be a very subordinate one in this northern architecture which I advocate. It should be the base of the sky-line capping, not the termination of the vertical building. For instance, if you had a cornice as the termination, how could the chimneys be carried out well? and yet a good solid stack of chimneys, in the hands of a good architect, is not only virtually but really a tower. It gives elevation, and forms a break. It may be to a great degree grand, and at the same time to as great a degree unsightly. Any stack of chimneys that requires crockery or metal topping is not only a failure but a solecism, both architecturally and actually. By building the stack in a mass, which is not consistent with the heavy cornices I speak of, you will secure the sky-line, and have domestic comfort for those within and architectural beauty for the building. I will give an instance of a great opportunity lost. If you stand at the north-east corner of the Green-park, you will have west the whole stretch of Piccadilly; south, the broken ground of the Green-park, terminating with some of the towers on the Palace of Westminster. The spires of several churches are also to be seen, and a glimpse is also got of Buckingham Palace, to which distance lends a charm which is said not to be found nearer. You will see also a large building which I believe is intended for an hotel. It is an offence to the eye; and why? Because the details are mean. If it had a Mansard roof, and a few stacks of chimneys well disposed, then at a distance of 200 yards you could mass these—but they are wanting; and where this building might be the turning point of a great town landscape, it is a huge block of deformity. This may be taken as an illustration of what I have endeavoured to impress. I do not know to whom the design of that hotel is owing, and therefore do not speak from personal feeling, but merely from observation of the edifice. Lower down, Bridgwater House also fails with chimneys. They are just sufficient to attract the eye, but not sufficient to make a rest for the eye which they attract. The same may be said of Stafford House, though they are both great masses, with good architecture more or less about them; but there is want of sky-line that is more especially needed owing to the slope of the ground in that direction. If you go to Hanover-square, to Hyde-park, or anywhere in Grosvenor-square, you will see the spire of that beautiful building, St. George's Church, producing, if it be a hazy day, a fine atmospheric effect. The site of the building may have been an accident, but the effect is great. Wren's western end of Westminster Abbey, with all its defects, is a great mass. Near it are Mr. Scott's very picturesque houses; and in the same neighbourhood, that monument of which a very high official was able to speak with such a superabundance of ignorance the other day.

In looking through London, it will be found that street scenery has not been altogether disregarded. There is the Euston Hotel, with its high elevation; there is also the Great Western, which is a great improvement; also the Grosvenor Hotel, near Buckingham Palace, which, without entering into a discussion of design, from its altitude boldly thrown skyward, from the stone of which it is built, and from its pyramidal roof, is to be admired. Looking at these edifices, nobody will say that the cause of architecture is not growing in London. There is a house lately erected on the west side of Bishopsgate-street—Mr. Wilkinson, architect—in which the form of Italian-Gothic has been introduced, and the cornices have been dealt with so as not to make the fatal mistake of looking round the corner; the pyramidal roof has been carried out, and those who approach the building will find a specimen of magnificent architecture,—a good outline and great beauty and delicacy of detail. Mr. Barry's schools at the corner of Endell-street are also works of very high merit: the height is great, and the gable, which is one of the elements of the sky-line, successfully handled. Gables can only be dealt with very gingerly in London, owing to the restrictions imposed by the Building Act—one of the objects no doubt being to guard against fires. That should be considered by architects, and it of course deprives them of full scope. Those buildings by Mr. Barry have a very good altitude, and a very sufficient gable, and inside the rooms are airy, light, and well distributed. That is a locality in which buildings of more or less merit will be found. The Schools of the parish of St. Martin show considerable study. The buildings I allude to are massed together, and the unity contributes to the great whole of London's future picturesqueness. They show what the town might be if fairly taken in hand by one person after another, each person aiming at some particular object. It is a mistake to think that in Amsterdam and Venice, or in other continental town, the buildings are all first-rate, or even tenth-rate. They are generally thirty or fortieth-rate. It is the *ensemble* to which they owe their effect, making them appear as if with respect to each it had been its design and intention to carry out one idea—and not to the mere mechanical piling of them together.

I will not take you through the city; but in the city there are many very sumptuous edifices round about our public buildings. There is Mr. Sarl's edifice, and the still more sumptuous Marine Insurance Office; then there is the somewhat fantastic Telegraph Office, behind the Royal Exchange, and also the small but pretty Schools of St. Mary's, Aldermanbury, erected within a few years by an architect seated in the city. If you proceed onwards to the poorer neighbourhoods, you will traverse street after street, uniform and monotonous and wretched, and your hearts will sink within you; yet here and there you will see a sample of what enlightened enterprise may carry out. In one of the poorest parts of Bethnal-green, Miss Coutts has built three great lodging-houses, two of which are complete, the third almost out of hand. They are solid masses on a huge scale, constructed of fire-proof material, with some pretensions to architectural elegance in their sky-line, and with a bulk and solidity which carry beauty with them. These are full of inhabitants, and are the representatives and correlatives of many streets and houses, massed into those great structures. How far the habits of the population may allow them to live in "flats" instead of houses is a matter which I cannot enter into; suffice it to say that here and there the experiment has been tried, and there has been enough success achieved to warrant its imitation, not merely by the architect but by the philanthropist.

I have taken you so far through a great deal of London, but have not yet entered on Belgravia, or Tyburnia, nor into that region which has been built in a quarter the name of which I am afraid I cannot accurately give. A few years ago I should have called it North Brompton, now I believe I should designate it South Kensington. Whether it is North Brompton or South Kensington, there are large houses and straight streets there. The height is greater in Tyburnia than in Belgravia, and in Brompton-Kensington than in Tyburnia. There is an improvement also in the roofing. Still there are many points which do not admit of so much praise. The material is almost confined to compo. The distribution of streets is that miserable one of right angles, square blocks, mutations of palaces—terraces in short, where we want houses. There is no harmony in them with ancient London. They are the last-built specimens of that style which you ought to avoid if you would make the metropolis picturesque. There is intended to be in one of these regions—South Kensington—a building, not yet risen above the ground, which we are told will be completed by the 1st May, 1862,—I mean the Great Exhibition building. I should have hoped and wished that in a lecture on the architecture of London, one might have wound up with a glowing panegyric on that very vast expanse of structure. I fear however, that with all desire to see the Exhibition successful, with all desire to give praise to every good intention, I cannot be very enthusiastic in laudation of that design. People's tongues have been tied because it is such a very good intention. It would seem like throwing dirt in the face of one's benefactor to criticise it. On the other hand, one does not like to cast reproach on anything that is like an effort of genius, or which might seem to be genius, emanating from quarters which possess the merit that a generous man always appreciates—that of self-instruction. But still I must express something not very far distant from profound disappointment at the design. It is allowable to be disappointed at a first effort. It is I hope not a crime to be disappointed at the large cupolas; and disappointment would not have been changed into approbation had the still larger central cupola continued to form a portion of the design. Here I will leave the Exhibition of 1862.

Those who have studied the progress of architecture cannot fail to have realised how much their resources in the way of material have been developed; how, instead of being confined to mere Bath and Portland stone, or the ordinary brick, we have got into the polychromatic development of real material. If you go into this style at all, you should do so boldly. The materials should be of the best sort, each in its proper place, and all well and strongly exhibited. We too often see the polychromatic style of architecture carried out with the yellow brick of London, with a few red bricks thrown in here and there. That will not do: the bands should be bold and broad, and the colours distinct. By some means, fair or foul, you should induce the brick-maker to give better bricks, such as are used in many of the brick buildings on the Continent. The magnificent Hospital of Milan is built of red bricks, with mouldings carried out in the same material—hard red bricks, which stand the wear and tear of centuries. If we could get that material in England, well and good; if not, we should go elsewhere for it. That which we use at present—the yellow, red, and black—fuses into a uniform chocolate under the London smoke. We should therefore use other tints, such as green. That colour might be used in painting window frames, and in other portions of the structure. But whatever colours are used—yellow, red, black, or green—they should be of superior quality, and be more boldly dealt with

I have treated exclusively of secular architecture, because I believe that the brunt of the battle now rests, so far as town architecture is concerned, with that particular branch. Churches which have both gables and spires take care of themselves. Ecclesiastical architecture has gone on improving, and has contributed, more than anyone has an idea of, to the picturesqueness of London; and I leave it as it is, not because I do not realise its great importance in every way, or underrate it, but because it is not the point which requires expansion and improvement.

I have hardly in the course of the lecture used the words Renaissance, Gothic, or Classic. I have not adopted that reticence from cowardice, or from a desire to avoid the subject. I am a Goth—more than that, a Northern Goth; but I am anxious to beautify the Northern Gothic with the best points of other styles, namely, Italian-Gothic, and Italian-Italian—for now that nice distinction should be drawn. I am willing to give a welcome to the best features of Grecian and Italian Gothic, and to extend the highest admiration to buildings of those classical and various styles, either in or out of London. I look on St. George's, Hanover-square, as one of the best specimens of picturesque architecture. Then there is that magnificent structure which you see when looking up Ludgate-hill—the forest of city spires to be seen wherever the eye turns—and the grand conceptions of Hawksmoor, who learned his lessons not in Italy, but on the Rhine. If you look at St. George's-in-the-East, you will realise the inspiration which he must have drawn from styles very little appreciated by men in those days. I am ready to give credit wherever credit is due—wherever conception and originality get play. I am a Northern Goth in conviction, not prejudice; because I believe the Gothic best fulfils certain general rules of taste which ought to be applied in London. If you have gone with me in treating houses as units, not as component parts of terraces; if, as I have appealed to you to do, you would play with the sky-line, and make the cupola, the pyramid, and the tower the main features of that sky-line; if you attend to design, and adopt judicious variety of colour in the materials, then I leave it to your judgment to answer in what style you find the best exemplification of all these principles. I appeal to your judgment; and the more calm, the more cold, the more critical that judgment is, the better, for then you would be the more likely to answer—"The Gothic is the style with which we could best grapple with these problems." If you did not say so, I should be much surprised. My endeavour has been to point out how, little by little, you all can work, as it were, like ants; so that contributing by small degrees to the great heap, you may deal with this London of ours—this vast, sometimes cold, often foggy, this northern, this great, this inimitable London—and may each in his own measure help to convert it into a picturesque city, in conformity with the natural variations of its soil and those rules of architecture which you have learned in northern climates. London will be a picturesque city if you set your shoulders to the wheel. Its picturesqueness will not be the picturesqueness of abrupt rocks and deep valleys, such as you have in Edinburgh; but a picturesqueness in which the vastness of the whole mass of the metropolis much more than compensates for those accidental advantages,—where the thousands and tens of thousands of the houses, its numberless streets, and the number of reconstructions that go on day after day, may, with a very small amount of talent expended upon them, produce a great result. The very highest architectural talent is now available in London. The very highest talent is used here and there, and in a great many cases a secondary amount of talent; and that secondary talent, imitating the higher, will carry on the great work which we all desire to see accomplished. If there was only something like unity of intention and desire to build for the sake of the town itself, and not merely for the individual structure—with a true idea of elevation and aspect as viewed, not from a few yards distant, but from whatever point the perspective could be gained; if, above all, the builders could be got hold of and made to understand that monotonous rows of tenth-rate houses, run up with starved designs in horrid terraces, are not commodious, beautiful, or even cheap; if houses were built for their own sake, as part of a whole, and not for the sake of any fancied uniformity with the house next door; if we could get into the mind of the builder that London is not a *caput mortuum*, but a great city in the course of rebuilding—then it might be rebuilt into something most picturesque and beautiful, by the multitudinous aggregation of units one with another. You might lay the foundation of converting this London of ours —which is so often (and so often justly) a mockery and laughing-stock both to people at home and abroad—into a metropolis which might in a century or two hence have a name all through the world for infinite variety, infinite beauty, infinite quaintness, and also infinite gracefulness of architecture.

IMPROVEMENTS IN THE WARMING OF BUILDINGS.

Some improvements in the warming of buildings have recently been made and patented by Mr. T. Phillips, of Skinner-street, Snow-hill, London. For warming a conservatory or greenhouse the patentee employs a cylindrical apparatus, with a plain conical or ornamental top fixed externally at one end of the structure. To this apparatus the gas is conveyed from a simply constructed gasometer, the size of which is regulated by the extent of the area to be warmed. Near the base of this cylindrical standard a set of gas jets are introduced, which are fixed on what is termed by the inventor a "patent swing burner"—very ingeniously contrived, so that the lighting is effected outside and the jets afterwards swing into their proper position within the cylinder in working order. Over the jets provision is made for the reception of cold water, conveyed into the standard by a pipe which enters immediately over the gas jets, when above this a pipe is inserted through which the water flows after having been heated by the gas. It is then conveyed by means of branch pipes in the directions required. One advantage of this system is, that when employed in structures for horticultural and similar purposes, the heat can be maintained at a uniform temperature throughout the whole night, without personal attention. Another advantage is, that in places distant from gas-works, an apparatus can be readily constructed, on so simple a plan that it may be easily managed by a lad, by which gas can be made at the rate of 2*s.* or 2*s.* 3*d.* per 1000 feet.

Mr. Phillips' arrangements are equally suitable to the warming of churches, picture-galleries, and public buildings generally. The apparatus in which the gas is generated may be of an ornamental character. The patentee has also introduced for lighting churches, chapels, and other buildings, a new light, by which greater brilliancy of illumination is obtained with half the number of burners, and at a much less cost than by the mode usually employed.

It would appear that the inventor's cooking apparatus has been adopted by the government for military and other establishments. It varies from 1 foot to 5 feet long by 2 ft. 6 in. wide and 3 feet high; and is so contrived that its various divisions are independent of each other, and the arrangements for the control of the heat are such that the singeing of a feather or the roasting of a hundredweight of meat may be effected at pleasure. One of the large size is in use at the garrison hospital, Chatham, and is said to be a perfect success. It carries on simultaneously the processes of roasting, baking, boiling, and stewing, for 500 men, at an expenditure of about 2*s.* 6*d.* worth of gas.

The baths for domestic purposes are simple in their construction, and have the great advantage that the water can be maintained at a uniform temperature while in use. They are so contrived as to be readily removed to any part of the house.

UNITED STATES PATENT LAW.

An Act in addition to an "Act to promote the progress of the Useful Arts.
Approved March 2, 1861.

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, that the Commissioner of Patents may establish rules for taking affidavits and depositions required in cases pending in the patent office, and such affidavits and depositions may be taken before any justice of peace, or other officer authorised by law to take depositions to be used in the courts of the United States, or in the state courts of any state where such officer shall reside; and in any contested case pending in the patent office it shall be lawful for the clerk of any court of the United States for any district or territory, and he is hereby required, upon the application of any party to such contested case or the agent or attorney of such party, to issue subpœnas for any witnesses residing or being within the said district or territory, commanding such witnesses to appear and testify before any justice of the peace or other officer as aforesaid, residing within the said district or territory, at any time and place in the subpœna to be stated; and if any witness after being duly served with such subpœna shall refuse or neglect to appear, or after appearing shall refuse to testify (not being privileged from giving testimony), such refusal or neglect being proved to the satisfaction of any judge of the court whose clerk shall have issued such subpœna, said judge may thereupon proceed to enforce obedience to the process, or to punish the disobedience in like manner as any court of the United States may do in case of disobedience to process of subpœna ad testificandum issued by such court; and witnesses in such cases shall be allowed the same compensation as is allowed to witnesses attending the courts of the United States; provided that no witness shall be required to attend at any place more than 40 miles from the place where the subpœna shall be served upon him to give a deposition under this law: provided also that no witness shall be deemed guilty of contempt for refusing to disclose any secret invention made or owned by him; and provided further that no witness shall be deemed guilty of contempt for disobeying any subpœna directed to him by virtue of this act unless his fees for going to, returning from, and one day's attendance at the place of examination, shall be paid or tendered to him at the time of the service of the subpœna.

2. That for the purpose of securing greater uniformity of action in the grant and refusal of letters patent, there shall be appointed by the President, by and with the advice and consent of the Senate, three examiners-in-chief, at an annual salary of $3000 each, to be composed of persons of competent legal knowledge and scientific ability, whose duty it shall be, on the written petition of the applicant for that purpose being filed, to revise and determine upon the validity of decisions made by examiners when adverse to the grant of letters patent; and also to revise and determine in like manner upon the validity of the decisions of examiners in interference cases, and when required by the commissioner in applications for the extension of patents, and to perform such other duties as may be assigned to them by the commissioner; that from their decisions appeals may be taken to the Commissioner of Patents in person, upon payment of the fee hereinafter prescribed; that the said examiners-in-chief shall be governed in their actions by the rules to be prescribed by the Commissioner of Patents.

3. That no appeal shall be allowed to the examiners-in-chief from the decisions of the primary examiners, except in interference cases, until after the application shall have been twice rejected; and the second examination of the application by the primary examiner shall not be had until the applicant, in view of the reference given on the first rejection, shall have renewed the oath of invention, as provided for in the 7th section of the act entitled "An act to promote the progress of the useful arts, and to repeal all acts and parts of acts heretofore made for that purpose," approved July 4, 1836.

4. That the salary of the Commissioner of Patents, from and after the passage of this act, shall be $4500 per annum, and the salary of the chief clerk of the patent office shall be $2500, and the salary of the librarian of the patent office shall be $1800.

5. That the Commissioner of Patents is authorised to restore to the respective applicants, or when not removed by them to otherwise dispose of such of the models belonging to rejected applications as he shall not think necessary to be preserved. The same authority is also given in relation to all models accompanying applications for designs. He is further authorised to dispense in future with models of designs when the design can be sufficiently represented by a drawing.

6. That the 10th section of the act approved March 3rd, 1837, authorising the appointment of agents for the transportation of models and specimens to the patent office, is hereby repealed.

7. That the commissioner is further authorised from time to time to appoint, in the manner already provided for by law, such an additional number of principal examiners, first assistant examiners, and second assistant examiners, as may be required to transact the current business of the office with despatch, provided the whole number of additional examiners shall not exceed four of each class, and that the total annual expenses of the patent office shall not exceed the annual receipts.

8. That the commissioner may require all papers filed in the patent office, if not correctly, legibly, and clearly written, to be printed at the cost of the parties filing such papers; and for gross misconduct he may refuse to recognise any person as a patent agent, either generally or in any particular case; but the reasons of the commissioner for such refusal shall be duly recorded, and subject to the approval of the President of the United States.

9. That no money paid as a fee on any application for a patent after the passage of this act shall be withdrawn or refunded, nor shall the fee paid on filing a caveat be considered as part of the sum required to be paid on filing a subsequent application for a patent for the same invention. That the three months' notice given to any caveator, in pursuance of the requirements of the 12th section of the act of July 4th, 1836, shall be computed from the day on which such notice is deposited in the post-office at Washington, with the regular time for the transmission of the same added thereto, which time shall be endorsed on the notice; and that so much of the 13th section of the act of Congress, approved July 4th, 1836, as authorises the annexing to letters patent of the description and specification of additional improvements, is hereby repealed, and in all cases where additional improvements would now be admissible independent patents must be applied for.

10. That all laws now in force fixing the rates of the patent office fees to be paid, and discriminating between the inhabitants of the United States and those of other countries which shall not discriminate against the inhabitants of the United States, are hereby repealed, and in their stead the following rates are established:—On filing each caveat, $10. On filing each original application for a patent, except for a design, $15. On issuing each original patent, $20. On every appeal from the examiners-in-chief to the commissioner, $20. On every application for the re-issue of a patent, $30. On every application for the extension of a patent, $50; and $50 in addition on the granting of every extension. On filing each disclaimer, $10. For certified copies of patents, and other papers, 10 cents per hundred words. For recording every assignment, agreement, power of attorney, and other papers, of 300 words or under, $1. For recording every assignment and other papers, over 300 and under 1000 words, $2. For recording every assignment or other writings, if over 1000 words, $3. For copies of drawings, the reasonable cost of making the same.

11. That any citizen or citizens or alien or aliens, having resided one year in the United States, and taken the oath of his or their intention of becoming a citizen or citizens, who by his, her or their own industry, genius, efforts, and expense, may have invented or produced any new and original design for a manufacture, whether of metal or other material or materials, and original design for a bust, statue, or bas-relief, or compositions in alto or basso-relievo, or any new and original impression or ornament, (or) to be placed on any article of manufacture, the same being formed in marble or other material, or any new or useful pattern, or print, or picture, to be either worked into, or worked on, or printed, or painted, or cast, or otherwise fixed on any article of manufacture, or any new and original shape or configuration of any article of manufacture not known or used by others before his, her, or their invention or production thereof, and prior to the time of his, her, or their application for a patent therefor, and who shall desire to obtain an exclusive property or right therein to make, use, (and sell) and vend the same or copies of the same to others, by them to be made, used, and sold, may make application in writing to the Commissioner of Patents expressing such desire: and the commissioner, on due proceedings had, may grant a patent therefor, as in the case now of application for a patent, for the term of three and one-half years, or for the term of seven years, or for the term of fourteen years, as the said applicant may elect in his application; provided that the fee to be paid in such application shall be, for the term of three years and six months, $10; for seven years, $15; and for fourteen years, $30: and provided that the patentees of designs under this act shall be entitled to the extension of their respective patents for the term of seven years from the day on which said patents shall expire, upon the same terms and restrictions as are now provided for the extension of letters patent.

12. That all applications for patents shall be completed and prepared for examination within two years after the filing of the petition, and in default thereof they shall be regarded as abandoned by the parties thereto, unless it be shown to the satisfaction of the Commissioner of Patents that such delay was unavoidable; and all applications now pending shall be treated as if filed after the passage of this act; and all applications for the extension of patents shall be filed at least ninety days before the expiration thereof, and notice of the day set for the hearing of the case shall be published, as now required by law, for at least sixty days.

13. That in all cases where an article is made or vended by any person under the protection of letters patent, it shall be the duty of such person to give sufficient notice to the public that said article is so patented, either by affixing thereon the word patented, together with the day and year the patent was granted, or when from the character of the article patented that may be impracticable by enveloping one or more of the said articles, and affixing a label to the package or otherwise attaching thereto a label on which the notice with the date is printed; on failure of which, in any suit for the infringement of letters patent by the party failing so to mark the article the right to which is infringed upon, no damage shall be recovered by the plaintiff, except on proof that the defendant was duly notified of the infringement, and continued after such notice to make or vend the article patented. And the 6th section of the act entitled an "Act in addition to an act to promote the progress of the useful arts," and so forth, approved August 29th, 1842, be and the same is hereby repealed.

14. That the Commissioner of Patents be and is hereby authorised to print, or in his discretion to cause to be printed, ten copies of the description and claims of all patents which may hereafter be granted, and ten copies of the drawings of the same when drawings shall accompany the patents: provided the cost of printing the text of said descriptions and claims shall not exceed, exclusive of stationery, the sum of two cents per hundred words for each of the said copies, and the cost of the drawing shall not exceed fifty cents per copy: one copy of the above number shall be printed on parchment, to be affixed to the letters patent: the work shall be under the direction and subject to the approval of the Commissioner of Patents, and the expense of the said copies shall be paid for out of the patent fund.

15. That printed copies of the letters patent of the United States, with the seal of the patent office affixed thereto, and certified and signed by the Commissioner of Patents, shall be legal evidence of the contents of said letters patent in all cases.

16. That all patents hereafter granted shall remain in force for the term of seventeen years from the date of issue; and all extensions of such patents is hereby prohibited.

17. That all acts and parts of acts heretofore passed which are inconsistent with the provisions of this act, be and the same are hereby repealed.

NOTES OF THE MONTH.

The Dalhousie Institute Competition.—The Committee of the Council of the Dalhousie Institute appointed to select the designs from those submitted in competition, have adjudged the first prize of Rs. 3000 to Mr. C. G. Wray, Executive Engineer, Ramghur Division, Hazareebagh; and the second prize of Rs. 1000 to Mr. W. S. Granville, 7, Harrington-street, Calcutta. A design by Mr. John Toner, of 38, John-street, Bedford-row, London, was held by the committee not to have complied with the terms of the competition so as to admit of its being placed, but it was considered to possess such peculiar merit that it was determined to award to it an extra prize of Rs. 500. Seventeen designs were submitted for the building—five being sent from England, and twelve from India. The successful designs and estimates are to be carefully revised with a view to the speedy submission of a design for the approval of the government.

Roman Remains.—The city of York, the ancient Eboracum, is a prolific field for Roman remains. Very lately some interesting remains were found in the digging of the foundation for a house on the Mount, the southern suburb, which was that part of the city in which the Romans interred their dead, and it is not very far from the hill erected to the memory of the Emperor Severus. Among the articles found are various articles of pottery, either sepulchral urns or vessels of domestic use, including one of the small earthenware vessels employed in feeding infants by the hand, of which some specimens may be seen in the museum of the Yorkshire Philosophical Society. A very perfect and beautiful example was also found of the glass jar which sometimes took the place of pottery as a receptacle for the ashes of the dead. When extracted from the earth it was half filled with bones. The glass is partially opalised by long lying in the ground, but it has escaped fracture. The most curious of the antiquities discovered here is a tablet of grit-stone, dedicated by her father to the manes of Cornelia Optata, who died at the age of 13. It is in hexameter verse, and the father, bewailing his hard lot, declares that he has placed an image of his daughter over the handful of ashes which alone remained of her. The upper part of the tablet which contained this figure has been broken off, only the feet remaining.

Chertsey Abbey.—The site of this ancient abbey, of which no remains are above ground, has been recently purchased by Mr. T. R. Bartrop, one of the honorary secretaries of the Surrey Archæological Society. It is his intention, during the present year, to have the ground thoroughly excavated, when no doubt many interesting relics will be found. In 1855 it was partly examined, and a splendid set of encaustic tiles discovered, which are now in the South Kensington Museum.

British Association for the Advancement of Science.—The thirty-first meeting will be held in Manchester, September 4th, 1861, under the presidency of William Fairbairn, Esq., LL.D., F.R.S. The local sub-committee of Section A (Mathematical and Physical Science) for the ensuing meeting of the British Association at Manchester, considering that an Exhibition of Telegraphic Machinery, illustrating its gradual development, would prove interesting and instructive, has determined if possible to arrange such an exhibition. With this view the committee are seeking from those connected with this subject contributions of instruments, batteries, or specimens of insulation, &c., showing the history, progressive improvements, and present condition of telegraphy. Persons willing to assist the committee are requested, at their earliest convenience, to forward a statement of what instruments or specimens they would be disposed to contribute. It is proposed to illustrate the practical working of the various instruments by opening communications on one evening to the principal cities of this country and the Continent—say to London, Aberdeen, Dublin, Cork, Berlin, Vienna, &c.; and the committee will be glad to know upon whom they may depend for aid in establishing these communications, and to what places it may be desired to work through special wires to be extended to the Free Trade Hall, and what amount of accommodation will be likely to be required in the building. Portraits of men eminent in the science of telegraphy, photographs of telegraphic works or apparatus—in short, anything calculated to increase the interest of the exhibition, will be gladly received by the committee. Communications should be addressed to R. B. Clifton and Thomas Heelis, the hon. secretaries of the Section.

Royal Institute of British Architects—Presentation of Prizes.—The prizes have been awarded to the following gentlemen:—To Mr. Walter Paris, Fergusson's 'Handbook of Architecture,' for the best design for a literary and scientific institution. To Mr. Richard C. Carpenter, Petit's 'France,' for the second best design for ditto. To Mr. Edward Tarver, Gwilt's 'Encyclopædia,' for the best set of monthly sketches. To Mr. Walter Paris, 'Parker's Glossary,' for the second best ditto. The £50 prize claimed by Mr. Thomas Vaughan, jun., of Stoke Newington, the successful competitor for the Soane Medallion in 1859, was awarded. This gentleman being abroad, his father attended for him and received the prize, the president requesting him to convey to his son the congratulations of the Institute. The president then presented to M. J. H. Le Sueur her Majesty's gold medal, and said that the Institute had great pleasure in recording the name of that gentleman among its most illustrious members.

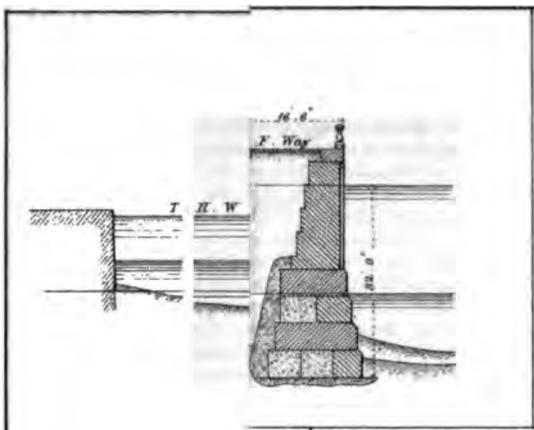
The Austrian Engineers' Union.—Two prizes are offered for the ensuing year, one of 400 German dols., and a second of 200 dols., for a historical and theoretical account of the latest roofs of wood and iron, beginning at 8 fathoms, up to the largest accomplished width of span. Two other prizes of like amount are offered for a historical, statistical, and critical account of the apparatus and means used for greasing railway carriages. Competitors for these prizes must send in their contributions before the end of October 1862. Persons wishing to compete for these prizes should apply for prize lists to the *Ingenieur-Verein*, Vienna.

Giffard's Injector.—The principle of Giffard's Injector appears to have been known upwards of a century ago. In 1753, Richard Savery, of Birmingham, published a book in which he gave a plan and description of an apparatus for raising water by steam. A conical nozzle, discharging a jet of steam, was shown within another similar nozzle, as in the Injector, the water being thus drawn up through and discharged from the annular passage. Among other copies of Savery's book, one is now preserved at Messrs. Elkington and Mason's, of Birmingham.

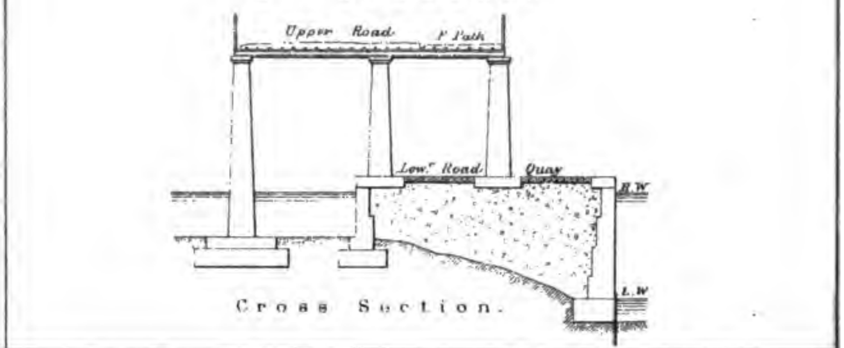
India-rubber and Gutta-percha Cables for Telegraphic Wires.—Seven manufacturers having furnished Prof. Wheatstone with a sample of their coated cables, and he having carefully tested each separately, the professor records—"1. That india-rubber surpasses all other materials in the smallness of the amount of its inductive discharge, and the perfectness of its insulation. 2. A coating of india-rubber is fully equal to a gutta-percha coating of double its thickness." He further says—"Messrs. Silver's india-rubber maintains an insulation almost perfect up to 92° Fahr., whilst gutta-percha is very considerably affected. Silver's india-rubber retains its high insulation with little or no change, and preserves nearly the same amount of discharge from 32° to 165° Fahr."

The New Houses of Parliament.—A report has been issued by the Royal Commission appointed in 1841 to inquire whether advantage might not be taken of the rebuilding of the Palace of Westminster for promoting and encouraging the fine arts. With regard to paintings, the commissioners have found that under existing conditions of lighting, oil pictures prove altogether unfit for the purpose; and they have therefore restricted the works now in progress to fresco or to the water-glass process practised in Germany. With regard to statues, a committee consisting of the Prince Consort and Lords Stanhope and Llanover have recommended in addition to Gibson's marble statue of her Majesty, already completed for the Prince's Chamber, a series of thirty-seven, comprising Edward the Confessor, Harold, and then from William the Conqueror downwards; twenty on the landing-places to be of metal, the other seventeen of white marble; and they recommend that Mr. W. Theed be invited to undertake two of the latter (William IV. and George IV.), and Mr. T. Thornycroft other two (Charles I. and James I.) at £800 each. Accordingly the report proposes that the vote this year be £3200, instead of the usual £4000, for the balances of former grants in hand for payment of works in painting are in advance of those works.

New German Church.—The foundation stone of a new German Evangelical Church was laid, on the 27th ult., in Hatton-street, Islington. The design is by Mr. T. W. Constantine, architect, London. There were seven competitors. The edifice is intended to accommodate between 300 and 400 persons.

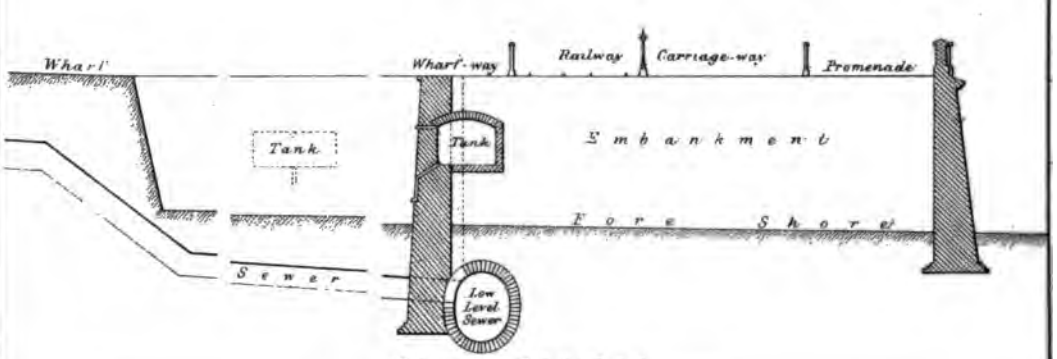


Mr A. DOULL.



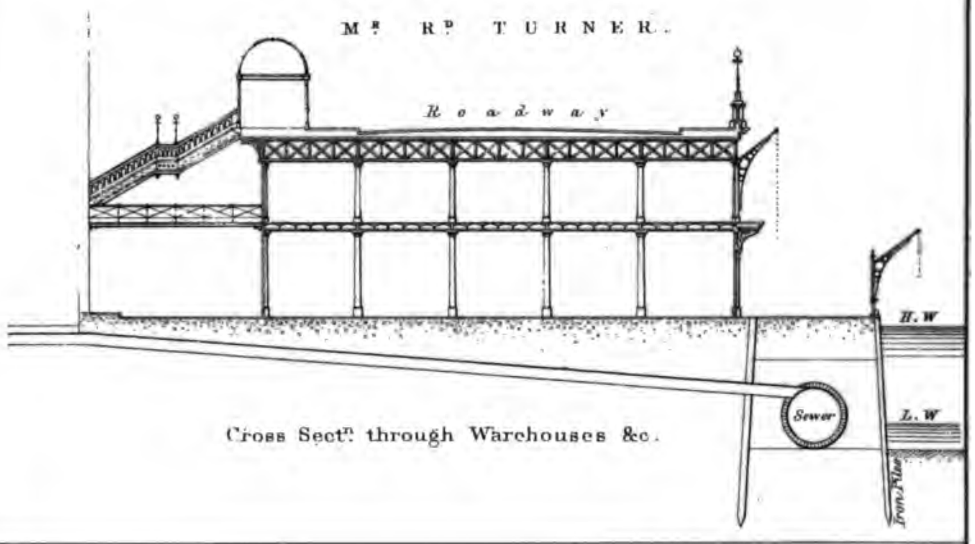
Cross Section.

Mr STANFORD.

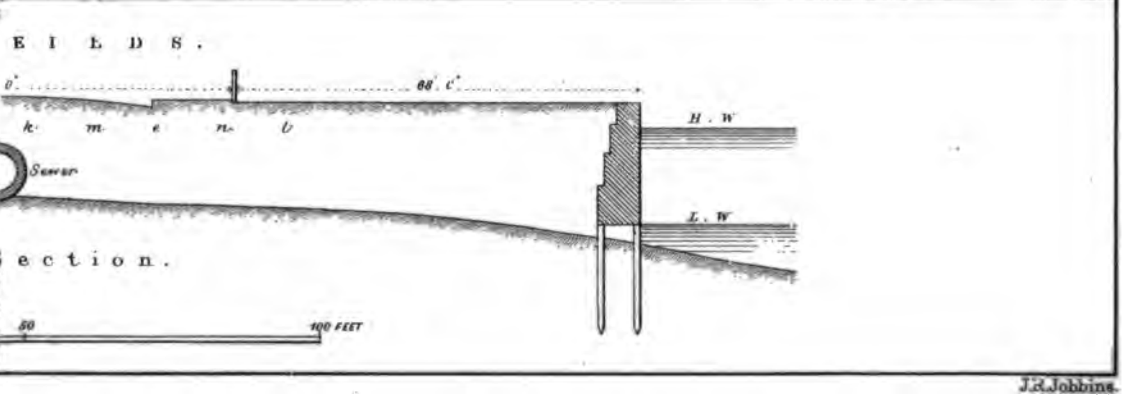


Cross Section.

Mr Rd TURNER.



Cross Sect^{n} through Warehouses &c.



J.R.Jobbins.

THE EMBANKMENT OF THE THAMES.

At a recent meeting of the commissioners the chairman stated that they had arrived at the opinion that at Hungerford the embankment should be filled up solid from the present shore, and should extend to the pier of the bridge, having a projection of about 300 feet; and that at Blackfriars it should project 130 feet from the existing abutment of the bridge, with access for barges to the wharves behind it. The designs submitted for the new Blackfriars-bridge would have to be prepared in accordance with the contemplated position of the embankment.

Probably few persons are aware of the great extent to which encroachments have been made on the river, and of the urgent necessity which there consequently exists for some comprehensive scheme which shall at once and for ever bound the river with a uniform shore. Mr. Page, in the course of his evidence before the commissioners, presented a copy of a plan of the Thames as it existed in the seventeenth century, from which it appeared that since that period the following among other encroachments had been made:—

The embankment made in 1767, in connection with the Blackfriars-bridge, 2560 feet in length, advanced into the river to an extent, at Whitefriars-dock, of 200 feet; the embankment in front of Arundel house and gardens, 700 feet in length, advanced 60 feet into the river; the embankments for the present Somerset-house and Savoy, making an aggregate length of 950 feet, advanced into the river from 50 to 110 feet. The embankment for the Adelphi in 1770, a length of 800 feet, projected from 90 to 120 feet. The embankment for Hungerford-market Wharf, 230 feet in length, projected 140 feet. The embankment at Scotland-yard and Fife-house, 340 feet in length, projected from 30 to 100 feet. The embankments at Whitehall-gardens and the Old Bowling-green, 850 feet in length, projected from 60 feet to 100 feet. The embankment for old Westminster-bridge, and parts adjacent, 500 feet in length, projected from 30 to 100 feet; and lastly, the embankment in front of the old Houses of Parliament, 1030 feet in length, projected from 70 to 150 feet; while the recent embankment for the present Houses of Parliament, nearly 900 feet in length, projects before the last line from 80 to 100 feet.

In our present number illustrations of several of the designs submitted are inserted, with descriptions in the majority of instances in the authors' own words, of nearly the whole of the various schemes. It will be seen by reference to our volume of 1844, to which we alluded last month, that while those schemes which propose an extension of the present shore may be considered as modifications of the plan proposed by Mr. Walker; those on the other hand which show detached embankments, are variations of the design first proposed in 1843 by Mr. Page.

The sections of the various designs are all to a uniform scale of 32 feet to an inch, and the whole will we think form an interesting and useful collection of the ideas which have been suggested on the subject.

Design by Mr. Thomas Page, M.I.C.E.

The plan laid before the commissioners by Mr. Page is nearly the same as was approved by her Majesty's Commissioners for Metropolitan Improvements in 1844, of which commission the present Duke of Newcastle was president. The modifications consist in increasing the width of the carriageway and footways. The principle on which it is based is the accommodation of the interests of the wharfingers with the desiderata for a public carriageway, promenade, railway, and low-level sewer; and also with the interests of the river as a port, which last consideration should have due weight in the present inquiry. It is evident that the plans for a solid embankment would involve such an amount of interference with the various wharves as would render it necessary to purchase most of the property at an enormous expense, while the conversion of so much water area into land by obstructing the free flow of the flood-tide, would prejudicially affect the scour of the river in the Pool.

All considerations lead to the conclusion that a detached embankment would be the best adapted to the various interests above mentioned. The plan comprises an embankment from Westminster-bridge to Blackfriars-bridge, on the line approved by the royal commissioners in 1844. At Westminster-bridge the line of the embankment would accord with the abutment of the new bridge, and the terrace of the Houses of Parliament. Between Westminster-bridge and Scotland-yard, the public promenade, 30 feet wide, would occupy the front of the embankment as far as Whitehall-palace, where the carriage traffic would enter, being carried across the side channel or tidal-dock to the main line of the embankment, 70 feet wide, on which it will run by a viaduct, so as least to interfere with the wharfingers.

It is proposed to fill the embankment up solid between Westminster-bridge and the north end of Whitehall-gardens, which would afford between Westminster-bridge and Richmond-terrace a valuable site for building purposes and low-level railway-station; and between Richmond-terrace and Whitehall-gardens, a space admirably adapted to the recreation of the public in the shape of pleasure-gardens. (See illustration, Plate XX.) The carriageway would commence at Whitehall-place, and extend thence to Blackfriars-bridge, on an embankment 70 feet wide, and at a level of 12 feet above Trinity high-water, passing under the second arch of Waterloo bridge to a point opposite Norfolk-street, where a junction would be formed with a communication to the Strand. The roadway would then gradually descend to a level of 5 feet above Trinity high-water, at which level it would pass in front of Temple-gardens, and leaving the river-line pass along a broad road in a diagonal direction to Tudor-street; by which means that portion of the traffic not requiring to go to Blackfriars-bridge would avoid the ascent which would be otherwise necessary, and the crowding and confusion from too great a concentration of traffic would be obviated.

From the point of junction at the east end of Temple-gardens with the proposed street to Blackfriars-bridge, the direct line of the embankment is continued by a viaduct of the reduced width of 50 feet (the traffic being lighter over this portion), and with spans of about 50 feet, rising at a gradual inclination of 2½ per cent. to Chatham-place, 19 feet above Trinity datum. Free access is thus given to the barges unloading at the City Gas Works. As observed by Mr. Page in evidence, the viaduct could be carried out as far as Southwark or London bridges on a high level, without damaging or interfering with the wharf property in that locality.

The side channel or tidal-dock would extend from Whitehall-gardens to the Temple, having five entrances with a headway of 9 ft. at high-water, and 18 ft. at half-tide, for the accommodation of the barges, which would obviate the necessity of swing-bridges.

It is proposed to carry the low-level sewer along the foreshore between the wharves and embankment, to avoid the expense, delay, and risk to property, in constructing it under the Strand and Fleet-street. Mr. Page in his evidence before the commission stated that nothing could be more simple and easy than to provide for and construct the sewer, as proposed by him, quite distinct from the embankment, in the foreshore of the river between the wharves and the embankment.

To execute the work in the least time and at the least expense, Mr. Page suggests that the lower half of the circle should be formed of concrete made with Portland cement and gravel: that the excavation being formed with sloped sides, a semicircular iron mould should be slung and fixed at the proper height, of a diameter 18 inches greater than the finished sewer, to allow of a lining of very hard bricks. This mould or inverted centre being in place, the concrete would be shot in on both sides, and the lower half of the structure rapidly completed, the 9-inch lining formed, and the remainder of the sewer, the sides and crown above the centre, built in brickwork. Mr. Page considers that this mode of proceeding possesses very great advantages, as it would not be required to pump out the water as for brickwork; it would be done with great rapidity, and an excellent and economical sewer would be secured along the shore of the river. The whole could be so arranged that the excavation for one length of sewer could be filled in immediately over the crown of a previous length. Mr. Page remarked that the adoption of this construction in considerable lengths of the great sewer works under the Metropolitan Board of Works, would be attended with a great saving of expense compared with the cost of brickwork.

The distance of the sewer from the shore in this design would probably vary; it would be brought much nearer the wharves if a railway were not formed. In reply to a question, Mr. Page stated before the commission that whether the invert of the sewer be constructed of brickwork or concrete, the ground would be equally pressed upon; but there would be soft places here and there, and in such places he would fill up with a certain depth of concrete. And further: that whether the sewer is made as proposed by him or whether it is made under the embankment, the ground would be equally firm or equally loose—the embankment would not assist the support of the invert; it would only assist the support of the sides of the sewer. When the sewer is made, of course if the ground is soft it would be piled, or excavated deep and filled up with concrete, depending upon the nature of the ground. Mr. Page went on to say that the same operation must be performed if the sewer is made in the embankment; and if it is made in the embankment more water would have to be contended against, that is, the works of the sewer would not be so soon out of the water as they would be if the sewer were made near the wharves. Taking into consideration the question of the foundation of the sewer, and supposing—which is a certainty—that whether the sewer is near the wharves or in the line of the embankment, the ground on which it rests must be either solid or solidified, the only advantage in placing the sewer in the embankment is that so much support is obtained against lateral pressure, and that support can be very easily secured by increasing the thickness of the concrete in which it is proposed to imbed it. If the sewer were in the embankment there would be a deeper shaft or greater depth of ground to pass through to reach it in case of repairs. Mr. Page proceeded to explain that any pressure on the sewer could be withstood by increasing the thickness of the concrete round it. It is proposed that the sewer should commence by a junction with the Victoria sewer at Scotland-yard, and be carried down to Queenhithe to join the great low-level sewer as proposed by Mr. Bazalgette.

Design by Mr. Bazalgette, M.I.C.E.

The design now laid by Mr. Bazalgette before the Royal Commission is the same or nearly so with that which, in conjunction with Mr. Hemans, he brought before the Parliamentary Committee last year, but owing to the passing of the London, Chatham, and Dover Railway Bill last session, and in consequence of a more minute inquiry into the value of the riverside property, he has been induced to offer to the consideration of the commissioners some modifications of his previous scheme as alternative propositions.

The scheme comprises a river-wall on both sides of the river, on the north side from Westminster-bridge to Queenhithe, and on the south side from Westminster-bridge to Hibernia-wharf, London-bridge; that on the north side with or without docks, in front of existing wharves, according to circumstances hereafter described, and that on the south side being filled in solid. The embankment on the north side carries a roadway 100 feet in width, which extends from Westminster-bridge to Queenhithe on the embankment; and is thence proposed to be continued of a reduced width of 60 feet, in a north-easterly direction to Cannon-street and the Bank. The low-level sewer is to be constructed within the embankment and along the proposed new street to Cannon-street, and along Cannon-street to the pumping-station at Abbey Mills.

The embankment wall is proposed to be constructed on both sides up to a level of 4 ft. above T.H.W.M., and is to be composed of cast-iron piling and plates with concrete backing (see illustration, Pl. XX.) Its encroachment into the river on the north side is indicated by a line passing from the abutment of Westminster-bridge close behind the north pier of Hungerford-bridge, and the second pier of Waterloo-bridge, and terminating at the first arch of Blackfriars-bridge, or continued behind the second pier of Blackfriars-bridge to the east side of Queenhithe-dock. On the south side a line representing the face of the wall would pass from the south abutment of Westminster-bridge, midway between the southern pier and the abutment at Hungerford, close behind the first pier of Waterloo, and onwards to the abutments of Blackfriars and Southwark bridges, and eventually would meet the new wall of Hibernia-wharf at London-bridge. The width of the river is thus reduced between Hungerford and Waterloo bridges from about 1400 to 860 feet, the narrowest part of the river at present between Southwark and London bridges being only about 660 feet in width. To make up for the deficiency of tidal-water caused by this reduction in the width of the river, as also with the object of improving the navigable channel of river it is proposed to dredge the bed so as to obtain a minimum depth of 5 feet below low-water level.

If docks be constructed to accommodate the existing trade, it is proposed to form five docks for the water-side traffic (see plan), designated after their localities, as the Westminster, Hungerford, Temple, Whitefriars, and Blackfriars docks, and occupying in all 21 acres; the intermediate portions of solid embankment amount to 15 acres exclusive of that part devoted to the roadway, which covers 20 acres more. Ten entrances in all are proposed for the docks, with headways varying from 8 to 18 feet above Trinity high-water, the level of the sills being restricted by the sewer to 14 feet below Trinity, a level which will leave a minimum depth of 6 feet of water on the sill two hours before and after high-water, during which period barges will be able to leave or enter the docks. The entrances will be closed by tidal-gates, so as to leave at all times a minimum depth of 6 feet of water in the docks, thus enabling the craft to be moved about within the docks at all times.

The roadway, 100 feet in width, starting from the level of Westminster-bridge, descends at a gradient of 1 in 60 to the level of the embankment-wall, 4 feet above Trinity high-water, at which level it is continued in front of Privy-gardens, rising again at a gradient of 1 in 60 from a point west of Hungerford-bridge which it passes under, leaving a headway of 16 feet, and then proceeds at the same gradient to a point about midway between Hungerford and Waterloo bridges; at this point the 100 feet is split into two roads of 40 and 60 feet wide respectively, the former being continued at the same gradient, and curved on plan to form an approach to Wellington-street; the latter or main road, 60 feet in width, being continued at a descending gradient of 1 in 83 to pass under Waterloo-bridge, leaving there a headway of 16 feet, and again ascending at a gradient of 1 in 280 to a point opposite Arundel-street, where it is met by a 40 feet curved road from Wellington-street, descending at a gradient of 1 in 50. From this junction the road is continued of its full width of 100 feet, at a level of 14½ feet above Trinity high-water, in front of the Temple-gardens. It was originally intended to carry the roadway over Blackfriars-bridge, with ascending and descending gradients on either side, but the passing of the Chatham and Dover Railway Bill has rendered this impracticable while the present bridge stands, and it is now suggested that if the embankment be still extended to Queenhithe, to pass it—the roadway—under the bridge, with a descending gradient of 1 in 50, leaving a headway of 18 feet under the bridge, a level approach 40 feet wide being extended to Chatham-place. On the east side of the bridge, the main road of the full width ascends at the same gradient to a level of 17½ feet above Trinity high-water, and continues level thence to Queenhithe. At this place a 40 feet branch roadway would descend at a rate of 1 in 50 to form a junction with Thames-street, and a 60 feet main road would ascend at the same gradient to pass over Thames-street, and continue on a level or nearly so to Cannon-street and thence to the Bank. The levels of the roadway generally are so designed as to admit of approaches at easy gradients to any of the streets now leading from the Strand, and other main thoroughfares to the Thames.

Where the roadway is elevated above the level of the embankment-wall it is designed to be carried on brick arches and iron girders, supported by iron cylinders resting on the gravel below the river bed. The appearance presented towards the river is that of a series of elliptical arches springing from octagonal piers, the whole being of cast-iron and highly ornamented. It is proposed to devote the space beneath the elevated roadway to the storage of goods or any similar purpose in connection with the water-side business. It is also proposed to carry out projecting landing-stages at intervals, at the same level as the roadway, so as to admit of goods being lifted direct out of the barges lying in the docks on to the waggons standing on the same level as the roadway, thereby avoiding the difficulty at present experienced in bringing waggons up the steep approaches from the wharves to the Strand. The river-side business will be further facilitated by the increased wharfage frontage in the docks, which is in some cases as much as quadrupled.

Owing to the difficulties and uncertainty arising from the construction of the bridge for the London, Chatham, and Dover Railway, and the probable reconstruction of Blackfriars-bridge; having regard also to the great value of the property east of Blackfriars-bridge, and the strong objection by the parties interested in that property to the construction of an embankment in front of their premises, Mr. Bazalgette has suggested an alternative proposition for an embankment-wall terminating at Blackfriars-bridge, with a roadway continued to New Cannon-street, along Mr. Bunning's proposed route of New Earl-street, and extended on to the Bank. In this case he proposes that the sewer should leave the river at Blackfriars, and be constructed from thence along New Earl-street to and along Cannon-street as before. To avoid the silting up which would probably take place in the bay left on the east side of the bridge, if the embankment were constructed on the lines previously described, Mr. Bazalgette purposes in this case to bring the embankment-wall further inland, to range with the first instead of the second pier of the bridge, so as to cause the tide to set into the bay at Queenhithe and wash away the mud.

Mr. Bazalgette has submitted estimates for these propositions, both with docks and also on the assumption that the provision of docks be abandoned, the wharf property be bought up, and the reclaimed ground filled in solid between the new and existing river walls. Whilst this treatment therefore involves the purchase of the river-side property and trade, it leaves an area of 32½ acres between Westminster and Blackfriars bridges, and 3½ acres between Blackfriars-bridge and Queenhithe, available as building ground or for other purposes. Mr. Bazalgette considers this feasible up to the western side of Blackfriars-bridge, but impracticable on the eastern side owing to the great value of the property on that side, and the comparatively small amount of land reclaimed. Mr. Bazalgette's estimates for his scheme and its several modifications are as follow:—

Estimate for Design with Docks.

NORTH SIDE.	Embankment from Westminster bridge toBlackfriars bridge	Embankment from Westminster bridge to Queenhithe.
Iron-faced embankment to level of 4 feet above Trinity high-water ...	£296,000	£384,000
Superstructure, roadway, and approaches	346,000	461,000
New street from Blackfriars to Cannon-street	550,000	
New street from Queenhithe to Cannon-street	...	175,000
New street from Cannon-st to Bank	300,000	240,000
Compensation, &c.	64,000	105,000
SOUTH SIDE.	£1,556,000	£1,365,000
Iron-faced embankment to level of 4 ft. above Trinity high-water (from Westminster-br. to Hibernia-wharf)	201,500	201,500
	say, 1,758,000	say, 1,567,000

Estimate for Design for Solid Embankment.

NORTH SIDE.	Embankment from Westminster bridge toBlackfriars bridge	Embankment from Westminster bridge to Queenhithe.
Iron-faced embankment to level of 4 feet above Trinity high-water ...	£240,700	£306,000
Superstructure, roadway, and approaches	346,000	461,000
New street from Blackfriars to Cannon-street	550,000	
New street from Queenhithe to Cannon-street	...	175,000
New street from Cannon-st. to Bank	300,000	240,000
Purchase of property...	750,000	2,050,000
SOUTH SIDE.	say, 2,187,000	£3,232,000
Iron-faced embankment to 4 feet above Trinity high-water (from Westminster-bridge to Hibernia-wharf)	201,500	201,500
	say, 2,389,000	say, 3,434,000

Design by Mr. A. M. Rendel, C.E.

In this design docks are provided within the embankment, having a depth of 12 feet at Trinity high-water. Access to them is provided by locks approached from the river by two large tidal-basins, one between Hungerford and Waterloo bridges, the other between Waterloo and Blackfriars bridges. The width of the river entrances of these basins is 240 feet. The roadway of the embankment is carried over them by iron arches in one single span, allowing a clear headway of 12 feet at Trinity high-water, and 30 feet at Trinity low-water. The depth of these basins at their junction with the river and at the locks is such, and the cills of the locks are laid at such a level, that the largest billy-boys can pass between the river and docks at any time of tide between high-water and dead low-water. Branch roads passing along each of the side walls of the basins and over the locks, afford four communications with the Strand and Fleet-street by means of streets already existing.

The embankment passes under all the bridges (except Westminster, which it joins), at a level of 6 feet above Trinity high-water, but rises to 15 feet above that datum at the tidal-basins. It finally forms a junction with the intended new Earl-street, to the eastward of the London, Chatham, and Dover Railway bridge. It affords a roadway 90 feet in clear width, with a towing-path on the inside, as shown in the illustration, Pl. XX. The embankment is continued beyond the road to near Queenhithe with a width of 30 feet, and incloses another dock approached by a lock at its extremity. The low-level sewer is carried under the docks in 6-feet cast-iron pipes, fitted together with bored and turned ends and laid without alteration of the levels determined on for it. It crosses the basins close under the wharves at their inner ends, so as not to interfere with the depth of water in them. The river-wall of the embankment is proposed to be founded at an average depth of 33 feet below Trinity high-water, on the clay. The part lying below low-water would be constructed of blocks of concrete or brickwork, weighing from 20 to 30 tons, laid in mortar-beds, but dry-jointed, from overhead gantries, with the assistance of divers, in a manner similar to that adopted with perfect success for the construction of the heads of the Portland breakwater by the late Mr. Rendel. A little clay backing would make this work quite water-tight. Above low-water the wall would be built in the usual manner of brick faced with granite and blue bricks. The estimate of the cost of the works of the above plan, prepared on very careful data, is £650,000.

Design by Mr. Fowler, Mr. Fulton, and Mr. Hemans.

This design comprises a solid embankment with a roadway 80 ft. wide and footway 28 ft. next the river, and a railway between it and the present shore. The space between the road and railway—and the rest of the embankment, except where space is reserved for docks—would be planted. Docks are provided within the embankment at the following places,—One at Hungerford, having an area of 5 acres; one at Norfolk-street, with an area of 1½ acre; and one at Whitefriars, with an area of 1 acre. Entrances to the docks would be formed below the embankment and railway, the headway ranging from 17 feet at the highest to 10 ft. 9 in. at the lowest point. The embankment would commence at Westminster-bridge and terminate at Blackfriars. The road would be connected at Chatham-place with the proposed new street from Cannon-street, and the railway would join the London, Chatham, and Dover Railway at New Bridge-street. The area of ground reclaimed from the river by this plan is about 49¾ acres; and the estimated cost, exclusive of compensation, is £700,000.

Design by Mr. Bidder, Mr. T. E. Harrison, & Mr. G. R. Stephenson.

This design consists of a broad embankment carried out from the existing shore, with docks occupying several acres, approached by regular locks, and within the line of the embankment and the existing shore. The additional breadth of ground would be applied to the building of warehouses, the frontages and rents of which would go in aid to carry out the works. There would be tramways parallel with the ordinary roads on the surface of the embankment, communicating with all the principal thoroughfares. There would also be combined with the embankment a low-level sewer. It is proposed to utilise the land reclaimed, to meet the expenditure, the construction of docks, and compensation to wharfingers.

Design by Mr. H. W. Sich.

It is proposed to build a river-wall of brickwork with granite coping, extending from Vauxhall or Westminster to Southwark-bridge, of the height of 2 to 3 feet above Trinity high-water, as shown in the illustration, Plate XX. Between this wall and the shore there would be an embankment, the height of the wall, and generally about 100 feet wide, and over this a series of brick piers, 50 feet apart, would support wrought-iron plate girders carrying a road 60 feet wide. This road would start from Westminster-bridge, pass under Hungerford, and rise to Waterloo-bridge. It would then descend so as to pass under the first arch of Blackfriars-bridge, and thence rise to Southwark-bridge, where it would terminate.

A series of cross-walls, 25 feet wide, would be placed where most convenient, connecting the embankment with the shores, and of the same height as the former. The spaces so inclosed would be formed into docks having each a communication with the river through the embankment; the width of the entrance would be 22 feet, guide piles being driven out in the river to enable barges to enter more easily. Single gates would be placed near the entrance, their sills being about 1 foot above low-water, so as to retain the water within the docks when the barges had entered. The cross-walls would enable the work to be carried on in sections, serve as a communication between the shore and the river at all times of the tide, and be useful for loading and unloading the barges in the docks.

The construction would be carried on as follows:—Outside the site of the river-wall part of a coffer-dam would be formed, and one or two cross-walls, as the case might be, run out to meet it. These would be formed by rows of iron-piling and sheet-piling 25 feet apart, 2 feet of concrete being put behind the piling next the water, and the remaining space between the piles filled in with ballast. The iron-piles not intended to be permanent would be formed with one flange of the groove for the sheet-pile screwed on, and as they would not require to be driven to any great depth the flange might be removed when that section of the river-wall was completed, the plates removed, and the piles drawn and again used; the same would be done with the inside row of piles for the coffer-dam, but these last would be of wood, sawn in half, with a flange screwed on as above for the sheet-piles between them, the hoops of the piles being removed and an iron wedge driven to tighten up the sheet-piles sufficiently to retain the puddle. The wooden-piles would be afterwards cut off, the ground excavated 2 feet between the rows, and concrete substituted to protect the wall against scour.

The low-level sewer would pass inside all the docks, and would be constructed in sections at the same time as the rest of the work. Where the sewer passes under the cross-walls, a brick-wall would be substituted above it for the iron-piling, to retain the filling.

Design by Mr. William Bardwell.

The embankment as proposed by Mr. Bardwell would extend from Bridge-street, Westminster, to Cannon-street, City; would be at least 100 feet wide, raised from two to three feet above high-water mark; with tramways, but no railroad, and without any buildings upon it. The embankment would pass beneath the bridges, and have lateral communications with the river-side streets on the one side, and spacious stairs and landing-places for steamboats. Tidal basins and spaces planted with trees would be provided within the embankment. The planted spaces, containing an area of about 12 acres, would be formed in front of the Temple and Privy gardens, Somerset-house, and along the south end of Surrey, Norfolk, and Arundel streets. The tidal basins would be about 18 acres in extent. The estimate for carrying out the whole, in the most substantial manner, is £450,000. (See illustration, Plate XX.)

Design by Mr. A. Doull, A.I.C E.

In this design a solid embankment is proposed from Westminster-bridge to Hungerford railway-bridge, as shown in the illustration, Plate XX., carried about 4 feet above Trinity high-water. About 30 feet broad of this embankment to be appropriated as a public promenade, and the reclaimed ground to be added to the adjoining gardens. From Hungerford railway-bridge the solid embankment would be continued at the same heght above Trinity high-water until within a short distance from Queenhithe, where the roadway would be placed upon piles to admit barges to the wharf where the space is much limited. The lower roadway would also be continued from Hungerford through Scotland-yard, and thus a low-level road for heavy traffic principally connected with the wharves would be formed from Upper Thames-street to Charing-cross.

There would be openings in the embankment, with gates to retain the water in the docks when desirable, and also swing-bridges over these entrances to admit straw-barges or craft with masts, but as the bridges could be raised some distance above the embankment there would be 5 feet clear headway above the highest point of spring-tides, which would admit coal-barges and all barges similarly laden without disturbing the bridges; and under no circumstances would it be necessary to open the bridges unless during one hour and a half before and the same time after high-water, and this would admit of an uninterrupted good level road from Upper Thames-street to Charing-cross during nine hours out of every twelve, also connecting with any of the adjoining streets where the levels would suit. This it is presumed would be a great boon to the wharfingers, and if additional wharfage accommodation should at any future time be necessary, jetties could be thrown out from the inside of the embankment.

A high-level road is proposed, commencing at Whitehall-place, passing under the railway-bridge at Hungerford, and then rising to the level of Waterloo-bridge, and continued to the level of Blackfriars and Southwark bridges, and terminating on the level of London-bridge. This roadway would be supported for the whole distance on cast-iron columns, placed about 80 or 100 feet apart. From Queenhithe to London-bridge the columns would be placed in the water so that neither the flow of the stream nor the access to the wharves would be interfered with. The upper roadway would be constructed in the first instance of a width to take four lines of light traffic, with a 12-feet footpath on the side nearest the river, and could easily be increased in width at any future period when an increase of traffic might require it.

The low-level sewer would be placed in the embankment or in a cast-iron pipe along the foreshore, where it would be sufficiently under the surface to guard against injury.

The foundation of the embankment-wall is proposed to be formed thus,—Cast-iron sheet-piling, 10 or 12 feet long, 2 or 3 feet broad, and about 2 inches thick, strengthened by ribs, would be driven down to the level of low water spring-tides, and but for the construction of the intercepting sewer this would be the level of the sill of the dock-entrances. Inside the sheet-piling the ground would be excavated to a depth of 4 or 5 feet below the top of said piles, so that the foundation of the embankment would be placed lower than the bottom of the river outside the piles. Concrete in blocks, lowered into position from a travelling-platform, would fill the excavated space to within 6 inches of the head of the piles. This would be surmounted by a course of blocks of stone about 4 feet high, and bringing the work about 3 ft. 6 in, above low-water. Should bricks be used for the facing of the wall, they would be built in cement in large blocks and lowered into position in the same manner as the blocks of concrete referred to. This mode of building in block courses could be continued until the work was sufficiently out of water to be carried on more advantageously by tide-work. By this mode of construction the work could be carried on rapidly and economically, without coffer-dams. Estimate, including sewer, £502,000.

Design by Mr. I. F. Stanford.

The author proposes an embankment for both sides of the Thames from Millbank to St. Paul's-wharf, with a promenade, carriageway, wharves, docks, and railway. Tanks are provided for sluicing the shores in the docks. The sewer is constructed in the embankment, with access to it at intervals from the wharfway (see illustration, Plate XX.) The manner of providing for the sluicing of the docks is by having tanks in the wharves, with wharfways in the embankment, also wharfways between the docks and at the ends thereof, so constructed with regard to height that they will be filled when the tide rises through the medium of an iron pipe, about 4 or 5 inches in diameter, with a self-acting valve at the inner end. And the supply from such tanks is proposed to be through a pipe passing from or near to the bottom of such tanks, down or within the face of the wharf or inner side of the embankments, to within about 3 feet of the bottom of such docks, and applied through the medium of a hose affixed by screwing it to the end of such pipe. Thus the sluicing would be performed without expense, very simply, and would require no skill in the operator.

Design by Mr. H. G. Coombs.

This consists of an embankment adjoining the present shore, and extending from Westminster to Tower-stairs, the low-level sewer being formed in it; and a roadway reaching from Westminster-bridge to London-bridge, and communicating with the several bridges in its transit, being formed on it. The embankment would commence at Westminster-bridge, on a line with the embankment wall of the Houses of Parliament, and proceed by an easy curve until it arrived at Waterloo-bridge, where it would merge into the present embankment of Somerset-house. Recommencing again at the east end of the Somerset-house embankment it would continue on its course to London-bridge, having an average width of 45 feet, forming an extension of the present wharfage on the bed of the river to that amount: from London-bridge to Tower-stairs it would be reduced to 15 feet in width, or merely of sufficient capacity to contain within it the construction of the sewer, which would here be turned inland, and be carried along Mint-street directly to its destination. Between Whitehall-stairs and Waterloo-bridge a dock would be formed between the embankment and the existing shore, and extending between these two points, having at its widest part a width of about 300 feet. The roadway would run on the embankment from Westminster-bridge to Whitehall-stairs, and from thence would rise gradually and be carried on iron columns above it, the space below the roadway affording access to the river and wharfage to the owners of property along the route.

Design by Mr. H. R. Newton.

From half-way between Blackfriars and Southwark bridges to the Horse-ferry at Lambeth, a viaduct or causeway would be placed on both sides of the river, 700 feet apart, this being the width of the river at the narrowest parts—viz. at Southwark-bridge and above the Horseferry, Lambeth. The viaducts would be 60 feet broad if without, and 100 feet if with, houses. The piers of causeway varying from 20 feet from centre to centre to as much as (under roadway only) 50 or 60 feet, and this merely at certain points for special reasons. By running a construction (in which the intercepting low level main sewer could be placed) through the causeway, and keeping the crown of it 7 feet or any other depth below Trinity high-water mark (so as ordinarily to allow barges to pass over at the openings at that period of the tide), the water on the bank sides would not fall away below that point, while for the regular variation of high-tide special openings would also be formed, being in fact the ordinary entrances for large craft. The roadway (the same height as Westminster and present Blackfriars bridges, to be level throughout, except at Waterloo-bridge, where it would go up an incline. Declines however are suggested in addition to pass under these bridges, so as to prevent the cross-traffic from impeding the thoroughfares. No communication except by staircases are necessary with new Hungerford-bridge, it being for the public only a foot-bridge. The additional construction on which the buildings would stand could be built at any time, as the roadway portion of the viaduct and the sewer under it is suggested to meet the embankment question; and by not touching the existing shores except at the terminals, or any point where communication might be required between them and the embankment, and at the bridges, the river-side property would not be interfered with, with the advantage of a canal, the water of which would be changed every tide. On carrying out the provision for buildings, it would convert the embankment into a government estate of the greatest immediate and prospective value; and at the same time, as a natural consequence, and without costliness or extravagance, would afford an opportunity of the highest artistic importance. The author declined to give his estimate of the cost of carrying out his design, in consequence of the chairman of the commission having informed him that his scheme, although very elaborate and beautiful, scarcely came within the scope of their instructions.

Design by Capt. W. S. Moorsom, M.I.C.E.

This design consists of an embankment along the present shore, inclosing a large sub-tramway or tunnel, with a subway for the sewer in the bottom part of the tunnel, the double tramway occupying all the other part of it. Along the top of the embankment the space next the river would be available for wharfage, having inside it a wide macadamised roadway, and also—next to the warehouses or buildings—a public footway. The embankment would extend from Westminster-bridge to Queenhithe, reclaiming space from the river, varying at places along the line from an extreme width of 150 feet to a minimum of 80 feet, available for roadway, footpaths, or promenades, public buildings, wharves, and private accommodation. The estimated cost of carrying out the plan is £588,562; against which Capt. Moorsom estimates the receipts to arise from the sale of reclaimed land and frontages at about £600,000, exclusive of £50,000 to be contributed by the Metropolitan Board of Works.

Design by Mr. J. Sewell, A.I.C.E.

This plan purposes to provide an embankment below high-water (which may be called a low-level embankment), for sewage, gas, or other mains, and a railway—all by private enterprise. As a consideration for the use of the foreshore, a railway company to provide a bank 5, 6, or 7 feet above low-water, laying down a cast-iron main to form the channel boundary of the foreshore; the space within to the wharves to be filled up by gravel dredged from the shoals in the river; and the bank to be completed by the usual sheet piling on the channel side of the main. The author states that this bank would have ample water way over it to the wharves, be cheaply made, easily kept, and water, gas, or sewage drains be more readily got at during low-water than street mains. The sewer would be laid to the natural fall of the river, and have a tidal door at each end, so that it might be flushed by each ebbing-tide. The sewer might be continued below London-bridge in a low-level bank down the river, which would at the same time form a bed for craft and improve the foreshore. Mr. Sewell is of opinion that so long as the scouring power of the tide is available to clear the mains, neither their dip to pass dock-entrances, nor their form, nor the route, whether by the river or by a shorter way, is material, provided that the mains emerge into the river at the points chosen for their separate discharge therein. On the south side of the river is proposed a similar low-level bank to that described for the north side. The railway and low-level embankment would commence at the city side of London-bridge, and proceed by or near the low-water line, on that side of the river, under all the street and railway bridges, to form junctions with the Crystal Palace line near Pimlico, and the West London line at King's-road, near Fulham. The length of the line would be about 6½ miles. The route has been selected, not as the shortest one, but as one that will give the utmost accommodation to both sides of the river. Opposite the wharves the line to be erected on iron columns of sufficient height to enable barges to pass underneath it to the wharves, at any available state of the tide, but opposite the Houses of Parliament and other places on banks or arches, as the architecture of the places may require. The line would be at from 100 to 220 feet from the wharves, and the supporting columns of the railway be no more in the way than the present piles, which divide a number of wharves: the existing waterways of the wharfingers and others would be preserved with the same freedom as now, whilst the embankment would make an excellent bed for craft during low-water.

Design by Mr. T. E. Weller.

The embankment commences in a line with the Houses of Parliament and ends near Queenhithe, with tidal or floating docks behind, and a viaduct 12 feet high on the embankment, from Whitehall-place to Broken-wharf. Thence it would be carried upon that projecting quay (across the entrance of Queenhithe) to the terminus behind Hambro'-wharf, Southwark-bridge, thus avoiding any encroachment upon the narrowest part of the river. Upon that projecting quay there are only wooden sheds for landing goods under, and the substitution of the roof of the viaduct in their place would provide an equal, if not better shelter. Where the embankment becomes too narrow to allow of any water-space behind it—between Blackfriars and Queenhithe—the effect on the wharves in those parts would simply be to extend them further into the river; and where desirable to build warehouses close to the edge of a wharf the plan allows of such arrangement. The upper viaduct would commence at Whitehall-place, alongside the lower one, and gradually rise high enough to pass on to the top of it a little before arriving at Waterloo-bridge: it would then remain upon it until approaching Blackfriars-bridge, when it would diverge to the north, and land in the angle of Chatham-place. The crossing of the London, Chatham, and Dover Railway at this point would prevent the viaduct passing over the bridge, and indeed it would be almost useless to carry it farther, inasmuch as the new diagonal street called New Earl-street, leading out of Cannon-street, will ultimately be continued to Chatham-place, and thus complete the line of road from Whitehall-place into the City. But the continuation of the under or railway viaduct to Southwark-bridge, Mr. Weller considers, would be of immense advantage to the traffic between the City and Westminster. The low-level sewer would pass easily beneath the embankment; and as the sewer is intended to turn inland at Queenhithe, it would part company with its protector just where the latter comes to its end.

Design by Mr. Thos. Thompson.

This embankment is proposed to commence at Westminster-bridge, in a line with the Houses of Parliament, to follow the bend of the river, pass under the railway bridge now constructing at Hungerford, under Waterloo-bridge, and in front of Somerset-house and Temple-gardens; thence the roadway gradually to rise above the embankment to a sufficient height, adjoining the new railway bridge to be constructed at Blackfriars, as to allow of the embankment underneath being used by the wharves between that point and London-bridge. The embankment to quit the river between Paul's-wharf and Southwark-bridge; to keep the present line of the bank at the narrow part of the river; to cross on a level the approach to Southwark-bridge; to enter the river again where it widens shortly below; to continue on and terminate at London-bridge on a level. The embankment at its commencement at Westminster would be only a few feet above high-water mark, to allow of the various streets now running out of Whitehall and the Strand opening on to it, and also to prevent injury to the first-class property already existing, and would continue on that level till its approach to Blackfriars. The embankment would consist of—1st, a footway or promenade, at least 20 feet wide, adjoining the river; 2nd, a roadway 60 or 70 ft. wide; 3rd, a 12-feet pavement: these widths might require some alterations on the approach to Blackfriars. It is proposed that the ground obtained from the river, where it did not interfere with the property already existing or which could not be purchased, should be used for the erection of public buildings or terraces of houses. The cost of the whole of the embankment from Westminster to the Temple it is estimated would not exceed £180,000. The ground recovered from the river, independent of the road between Westminster and the eastern end of Temple-gardens, would be about 25 acres in extent.

Design by Mr. H. H. Bird.

This design, which was illustrated by numerous and elaborate drawings, consisted of an embankment extending from Westminster to Queenhithe. There would be a road and railway, the latter running from Queenhithe to Hungerford, and thence by the end of Manchester-buildings, Parliament-street, and Victoria-street, to the Victoria Station of the London and Brighton Railway. Within the embankment docks would be formed, with lock-entrances to them. Mr. Bird also proposes the construction of a compensatory dock opposite Battersea church, and one at Fulham: by these means the flow of tidal-water would be increased, the water-level in the docks within the embankment maintained, while by letting out the water occasionally the scour of the river could be increased as found desirable. The estimated cost of the whole would amount to £700,000.

Design by Capt. Vetch, R.E.

Capt. Vetch proposes embanking the Thames from Westminster-bridge to Queenhithe-dock, following nearly the line of the plan laid down by Mr. Walker. He states that this is the line which would meet the requirements of the Admiralty. The line of embankment would take in two arches of Waterloo-bridge and one of Blackfriars-bridge. Capt. Vetch considers that if there were to be an uniform width of the river it would improve the current. When old London-bridge was removed it made a difference of 5 feet at Chelsea at low-water, but at high-water the tide rose 5 inches more than it had ever done before.

Design by Mr. R. Turner, C.E.

This design consists of an embankment with open wharves and landing-quay, and a low-level street adjoining the present warehouses. Above the embankment there would be a range of warehouses in front of the present wharf buildings, communicating by bridges with the existing premises, and the main roadway for the through-traffic would be carried above these. The low-level sewer is placed in the embankment, and the author also suggests that a roadway and railway might be constructed therein in tunnels, with vertical shafts for the passage of light and air from the wharf level above. The estimated total cost is £560,000. See illustration, Plate XX.

Design by Mr. F. W. Sheilds, M.I.C.E.

It is proposed in this design to construct a river-wall as an embankment face, a little beyond the line of low-water, with a solid embankment within it extending to the present shore, as shown in the illustration, Plate XX. A road, 80 feet wide, is carried on the level along the centre of this space, passing under Hungerford and Waterloo bridges, and communicating with all the existing streets. A breadth of land is thus left between the road and the new face wall, whereof the portions in front of their premises would be given up to the owners of the more valuable waterside properties, in order to furnish them a new water frontage in place of their present one, which would be separated from the river. These properties, whether business premises or pleasure-grounds, would thus retain all their present advantages, with large additions to their space.

The less important wharves are proposed by Mr. Sheilds to be bought up altogether, as with the reclaimed ground adjoining they would form a most valuable property, having frontages to the new main road and to the river, the proceeds of which would go far to diminish the cost of the undertaking.

The advantages claimed for this plan are, that while it provides an additional great thoroughfare, a site for a main sewer, and the improvement of the condition of the river, it offers a maximum of accommodation to the various private interests concerned at a minimum of cost. By replacing the wharves in their natural position next the river, it avoids the construction of docks and lock gates, and of the series of arches necessary to carry the main road over them; and reduces the work to the formation of a simple embankment. Should it be desired to carry the main road by the side of the river as a promenade, this plan admits of it with equal facility. The wharves in this case, or at least the less valuable ones along the portion of the embankment so treated, would be bought up, and done away with; and the reclaimed space within the road might either be laid out as ornamental grounds, or sold as first-class building land in reduction of the expenses of the work.

The cost of carrying out this design, exclusive of compensation to the owners of private property, is given in detail by the author. It amounts to £250,000; and includes the entire completion of the face wall, embankment, and sewer, the construction of an approach to Waterloo-bridge, the formation of all the new roads, and a sum of £20,000 for contingencies.

Design by Mr. W. Haggett.

By this plan the embankments are kept pretty much the height of the present quays, and consequently the adjoining property would not be depreciated in value. The embankments are recommended to be made about 100 feet wide on each side of the river from Millbank to London-bridge, in a series of easy curves in the present direction of the river, which would be left about 600 feet wide. On the north side the embankment would be 10,200 feet, and on the south 9300 feet in length; and the land thus reclaimed, of various widths, would be—on the north, 1,514,000 square feet, and on the south, 1,117,000 square feet; being together about 60½ acres. Although the outside or river wall would be solid throughout, with landing-steps for boats, it is proposed, instead of filling up, to arch over the residue of the space thus acquired for the following purposes, and make the street and quays over the whole. In the inner compartment against the present frontages would be laid the low-level sewer, which may be built at once; and in this space would also be placed the gas and water mains, which could at all times be examined without injury to the streets above. The next two compartments would be used or sold for stores, warehouses, and offices, with approaches from the quays or present houses; and the outer compartment, which would be sufficient for four lines of rails, might be used or sold for railway purposes, to take the heavy traffic from the docks and railways in the east to the west, so as to relieve the present streets, which could, if these the only sites are thus preserved, be carried out by private enterprise. The space thus arched over could then be formed into new streets and quays, the whole about 100 feet wide. Wherever there is wharf property, the quays, 20 feet wide, would be ornamentally separated from the streets—which in such places would still be 80 feet wide—beneath which the arches would be so arranged as not to interfere with the road above, but form corridors and additional stores from the new quays to the present buildings, for the owners thereof, and who would then have direct railway communication with all parts. In other places the entire width would be left open, and any additional land not required for the 100-feet street be planted as gardens, or used for building purposes hereafter. The clear space which would be left under the road and quays, after the river and other walls, piers, and works are completed, will amount to about 19,790,900 cubic feet. The approaches from all the present streets would be brought down to and finish on the proposed new roads—thus providing an outlet from every part to relieve the present overcrowded thoroughfares. The level would be kept so as not to injure the adjoining property, which would be the case if the streets were raised, as it would then interfere with the frontages.

SUBMARINE TELEGRAPHS.

The joint committee appointed at the close of 1859 by the Board of Trade and by the Atlantic Telegraph Company, to inquire into the construction of submarine telegraph cables, have just made their report, which has been presented to both Houses of Parliament, and been printed with the evidence in a voluminous blue book of 564 pages. The committee consisted of four gentlemen appointed by the Board of Trade—viz. Capt. Douglas Galton, Prof. Wheatstone, Mr. W. Fairbairn, and Mr. Bidder; and of the same number appointed by the committee of the Atlantic Telegraph Company—viz. Mr. E. Clark, Mr. C. F. Varley, Mr. Latimer Clark, and Mr. Geo. Saward,—all of them well known as civil engineers and electricians. They commenced their labours on the 1st of December, 1859, and sat at intervals till the 4th of September last; during which period they examined thirty-eight witnesses, and in addition to their evidence there is a copious appendix to the report—which occupies nearly as much space as the evidence—containing records of experiments and abstracts of various reports relating to the transmission of electricity through submarine telegraph cables, and to the insulators employed. The mass of information thus collected, and the opinions expressed by so many gentlemen who have been practically engaged in the construction and laying of submarine cables, and in investigating the mysterious condition of electricity when transmitted through submerged wires, cannot fail to produce valuable results, and may lead to the removal of the difficulties that obstruct the establishment of submarine telegraphic communication between distant countries; but at present the evidence is too conflicting, and the causes of the retardation of the electric current in passing through long submarine cables, are so imperfectly understood, that the principal immediate advantage gained is knowledge of what to avoid.

The report is divided into three general heads—under the first of which an account is given of the 11,364 miles of submarine telegraph cables that have been laid, of which however about 3000 miles only are in work; the second comprises the construction and laying of submarine cables; and under the third head the committee give a summary of the principles which they consider should govern submarine telegraph undertakings in future. In noticing the Atlantic telegraph, the committee attribute the failure of the enterprise "to the original design of the cable having been faulty, owing to the absence of experimental data, to the manufacture having been conducted without proper supervision, and to the cable not having been handled after manufacture with sufficient care." "We have had before us," say the committee, "samples of the bad joints which existed in the cable before it was laid; and we cannot but observe that practical men ought to have known that the cable was defective, and to have been aware of the locality of the defects before it was laid." This is a hard blow on all those who were concerned in the manipulation of the cable, and it may seem to come with additional force considering that four members of the committee were appointed by the Atlantic Telegraph Company, and that one of them was secretary to the undertaking. It may be said however on the other hand, that as it is the present object of the direct Atlantic Company to show that the failure of the cable was owing to causes within control, the charge of incompetency and neglect is made for that special purpose. It appears from the evidence of the witnesses who were engaged in laying the cable and in working it afterwards, that it was in a most defective state; and that even whilst laying the cable the electric communication was for a short time interrupted, as is supposed by the breaking of the conducting wire, and it was only restored by the accidental contact of the broken strand of wires when the strain upon the gutta-percha covering was removed. Even in its best condition there was a leakage of nine-tenths of the electricity transmitted, owing to defective insulation. One of the documents presented to the committee was a complete record of the messages sent from Valentia to Newfoundland and back during the twenty-three days that the communication was open—viz. from the 10th of August to the 1st of September inclusive. This curious record was presented, not by the Atlantic Telegraph Company, nor by anyone connected with it, but by Col. Shaffner, the American telegraphist, the promoter of the rival scheme by which it is proposed to connect Europe with the new world telegraphically by way of Greenland, Iceland, and the Faroe islands. It may be supposed that his object was to show the difficulty of transmitting messages through a continuous submarine cable of upwards of 2000 miles; and on looking at the results of the working on each day there does undoubtedly appear to be evidence that, even had the communication been continued, the messages transmitted during a day could have been very few. It required generally upwards of a minute to transmit one word, and the transmission was continually interrupted because the signals could not be understood. The first transmitted word read at Newfoundland was "Atlantic," on the fourth day; and on the fifth day the first connected message was received at Valentia. The message from the Queen to the President of the United States was sent on the seventh day, and from that time the signals improved and continued good until the twentieth day, on which no signals were received from Newfoundland. During that short period, when important messages on both sides were waiting to be transmitted, the following communication was received across the Atlantic: "Mosquitos keep biting. This is a funny place to live in—fearfully swampy." The operators appeared at that time to have had no apprehension that the means of transmitting information from the new world to the old would have been so soon ended. The last message sent from Valentia to Newfoundland, of which the following is a copy, may be adduced as a striking illustration of the uncertainty of human expectations. The words in italics were those only that were received: "*C. W. Field, New York,—Please inform* American *government we are now in position to do best to forward* their government messages to England. Saward, London;" and the last words received at Valentia were: "Right, right!" During the twenty-three days that the communication continued, there were transmitted from Valentia to Newfoundland 1474 words, and from Newfoundland to Valentia 2885; but a great number of those words were orders to repeat signals and directions about working the instruments.

The committee notice briefly the Red Sea and other telegraph cables which have been laid since the Atlantic, the failures which have occurred, and their causes, and thus conclude their comments on this part of the subject:—

> "It will be observed that the failures of all these submarine lines are attributable to defined causes which might have been guarded against. It is possible that as our experience progresses other causes of failure besides those already ascertained may be discovered, but we believe there are no difficulties to be encountered in laying submarine cables, and maintaining them when laid, which skill and prudence cannot and will not overcome."

In considering the next branch of their subject—the construction and laying of submarine cables—they pass in review the principal plans that have been devised for insulating the conducting wire and subsequently strengthening it, and they devote much attention to what is termed the induction of electricity in the insulating covering, which has proved to be the great electrical difficulty in transmitting signals through submerged wires of great length. This peculiar electrical effect was first made known in 1854, and it has been a source of annoyance and perplexity in all underground or submarine telegraph wires that extend above 100 miles, especially when those instruments are used in which the electric current continually passes in the same direction. The gutta-percha insulating covering produces the same electrical condition as if the wire were an elongated Leyden jar, of which the conducting wire is the inner coating, the gutta-percha the non-conducting envelope, and the water in which it is immersed the outer coating. A wire in this condition may be charged with electricity, and it may retain the charge so as to give a shock after its connection with the voltaic battery has been broken. This condition of the wire is commonly said to be produced by "induction;" that is to say, the positive or negative charge in the wire induces an equal charge of the opposite kind of electricity in the surrounding gutta-percha. Now it is well known, that when a large Leyden jar is discharged the whole charge does not immediately pass away, but a second, third, and even a tenth spark, may be observed on repeatedly applying the discharging rod. A similar effect takes place when a submerged wire is charged by contact with a voltaic battery; and the quantity of electricity retained in the wire, or the covering, after the transmission of a few signals prevents succeeding signals from being distinguished, for the wire continues charged with electricity for several seconds, according to the length of the wire. Some mathematical electricians think they have discovered the law which governs this phenomenon, and have given formulæ to determine the relative thickness of the wire and of the gutta-percha best adapted to prevent the obstruction: but the attempt to found mathematical formulæ on the very imperfect data at present possessed only tends to mislead, and the failure of the Atlantic telegraph may in a great measure be attributed to the application of such calculations. Instead of considering the telegraph wire as a *conductor of electricity*, it appears to have been regarded as *the receiver of an electric charge*, and that by making the interior wire as small as practicable, it would be the more readily charged and discharged. This notion of charge still holds possession of the minds of many of the electricians who were examined before the committee; but it was objected to entirely by Mr. Allan in his evidence, and without any attempt to mystify what is explainable by well-understood causes, he contended that the wire should be considered as a *conductor*, and that it should be so large as not to become "charged" with the electricity transmitted by it. It is indeed now generally admitted that the larger the conducting wire the better, but it is still attempted to prove by formulæ that a thick wire requires such a thickness of gutta-percha as would render the insulation a much more expensive matter than it has hitherto been. The evidence adduced on this point was contradictory, and tended to show that mathematical calculations cannot yet be brought to bear on the question, and that they may do much mischief by inducing the adoption of formulæ without experimental inquiry.

We cannot follow the committee through the various portions of their extended report. Even their "Summary of principles which should govern the construction and laying of submarine telegraphs" occupies too much space for us to extract entire, and we must content ourselves with briefly indicating what they are. They comprise, generally, the construction of the cable, and the laying and maintenance of it. Under the first head are included the conducting wire, the insulating covering, the external protection, and a general conclusion as to the form of cable; and under the second head the preliminary survey, the apparatus for laying submarine cables, and contracts for laying them, are considered.

The conducting wire, it is observed, should be formed of the material which possesses the highest conducting power which can be selected, and should be of some metal or alloy not liable to oxidise, nor subject to rapid variation in conductivity from change of temperature. The strand form is recommended as best, so as to prevent the fracture of one wire from rendering the whole cable useless.

Of the insulating covering the committee observe:—

> "Of the materials which have been submitted to us the best insulator by far is india-rubber; Wray's compound and pure gutta-percha nearly resemble india-rubber in its insulating properties.
>
> The induction discharge is directly as the length of a wire. The amount of induction discharge from wires of different diameters with coverings of various thicknesses of the same insulating material may be assumed to be, for practical purposes, directly as the square root of the diameter of the wire, and inversely as the square root of the thickness of the insulating envelope.
>
> Hence, by increasing the diameter of the wire and the thickness of insulating covering in the same proportion, the amount of inductive discharge remains the same. The force of a current in a voltaic circuit increases as the square of the diameter of the wire (the length of circuit being constant, and the resistance of the battery being inconsiderable as compared with that of the metallic portion of the circuit); consequently, if it be found inconvenient to increase the conducting wire and the insulating covering proportionately, greater advantage will be obtained by increasing the diameter of the wire than the thickness of insulating covering; for whilst the covering remains the same the induction discharge increases only as the square root of the diameter of the wire, whilst the force of the current increases as the square of the diameter; and if the insulating covering be varied, the conducting wire being constant, the strength of the current will remain the same, but the induction will only decrease as the square root of the thickness.
>
> India-rubber surpasses all other materials in the smallness of the amount of its inductive discharge and the perfection of its insulation. A coating of india-rubber is fully equal to a coating of the gutta-percha hitherto in use of double its thickness. Wray's compound and the recently manufactured pure gutta-percha, closely resemble india-rubber in both these respects. The mixture of imperfectly conducting materials with gutta-percha has the disadvantage of greatly reducing the insulation and increasing the induction. The interposition of cotton thread between the wire and an insulating coating considerably increases the induction and diminishes the insulation. The induction is augmented because the cotton thread, which is a bad insulator, increases the surface of the conductor; and the insulation is impaired, not only because the insulating coating is diminished by the thickness of the cotton, but probably also in consequence of the greater inductive action. The interposition of cotton between two layers of insulating material is equally disadvantageous. The interposition of a viscid insulator between two coatings of insulating material neither decreases the induction nor improves the insulation of the line, but the viscid fluid has a tendency to fill up air-holes or flaws in the insulating coatings. Generally speaking, the more perfect the insulating property of the material is, the less is its inductive capacity.
>
> India-rubber and Wray's compound are not perceptibly affected by any ordinary increase of temperature, but increase of temperature has a very decided influence in diminishing the insulation of gutta-percha. This substance is therefore not well suited for cables to be laid in tropical regions. Temperature affects the induction discharge only in so far as it affects the insulation.
>
> India-rubber and gutta-percha are subject to deterioration by exposure to the action of oxygen in the presence of solar light; but when light is excluded gutta-percha will remain for months, and india-rubber for a considerable period, unchanged in air, and both will remain unaltered for years in water when light is excluded; indeed sea-water is peculiarly favourable to the preservation of gutta-percha, especially when coated with Stockholm tar. As regards Wray's compound, we have seen a specimen of his No. 2 material, which it is stated has been exposed to alternations of temperature and exposure during two years, but sufficient time has not elapsed since its introduction to enable us to express a definite opinion as to its durability.
>
> Pressure greatly improves the insulation whilst it is being applied, and this effect is more perceptible as the substance is a worse insulator. But it does not appear that pressure asserts any influence on the amount of induction discharge."

The foregoing observations show us that no calculations can be made with mathematical precision respecting the proportionate thickness of the conducting wire and the insulating covering; for as some substances are stated to possess much less inductive power than others, the same rule could not apply to both.

Of the outer covering it is said, that it should be such as to protect the internal core against injuries or strains in laying, or in raising for repairs, against the attacks of marine animals, and against abrasion on a hard bottom; and it must be capable of having joints made with ease. It should also give the cable sufficient specific gravity to insure its sinking evenly. In alluding to shallow-water cables, one of the "principles" enunciated by the committee is, "the most desirable covering would, *if it could be found*, be a strong metallic covering not liable to corrode in sea-water, rather than iron wire covered with hemp or other material." For cables beyond the reach of anchors, and even of strong currents, the committee say—

> "It may be necessary to employ iron or steel wire to obtain the necessary strength for raising for repairs either during laying or after they are laid. In this case the danger from abrasion is less, and the iron or steel wire must be protected from corrosion by means of some outer covering. We think such an outer covering is to be sought in tarred yarn, protected by some cheap compound of gutta-percha or india-rubber. The wires by which strength is given should be laid on longitudinally, or with a very slow turn, and must be kept in place by a special binding, or by means of the covering compound. Cables of this general form may also, we believe, be made applicable to the greatest depths which will be met with. In any case the outer covering should be so devised as to prevent a strain coming on the core; and the specific gravity should be adapted to the depth, and be such as to insure the cable sinking evenly."

The committee enforce the necessity of more careful preliminary surveys than have been hitherto made before laying a submarine cable, and they suggest the desirability of contriving some instrument which would enable the actual bottom of the sea to be traced. The committee attribute the failures that have occurred in laying submarine cables principally to the employment of ships not properly constructed for the purpose, and they recommend that ships should be built specially for such purpose. The last of the principles which the committee enunciate relates to the contracts for laying submarine cables. They suggest that "a defined but limited pecuniary responsibility should be placed on the contractor, who must therefore be allowed a certain liberty in his arrangements."

The committee in the conclusion of their report look confidently to the future, and repeat the opinion they had before expressed, that the failures of the existing submarine lines "have been due to causes which might have been guarded against had adequate preliminary investigation been made into the question;" and they conclude by observing, "we are convinced that if regard be had to the principles we have enunciated, in devising, manufacturing, laying, and maintaining submarine cables, this class of enterprise may prove as successful as it has hitherto been disastrous." We sincerely hope that this conviction of the committee may be realised; and the vast variety of information bearing on the subject contained in the evidence and appendix of this report is calculated to bring about so desirable a consummation. We place more reliance on the results arising from a careful consideration of that information than on regard to the principles declared by the committee, which are in several instances but self-evident truths, or vague and impracticable recommendations. Some disappointment may be felt that the committee express no explicit opinion respecting the success of a direct Atlantic telegraph, which was it may be assumed the chief object they had in view; though it may be inferred from their expressions of confidence in submarine telegraphs generally, and from their attributing former failures to causes that may be guarded against, that they wish it to be understood that such an undertaking, if properly conducted, would be successful.

ON THE REVIVAL OF STYLES.*

By Rev. J. L. Petit.

It will I think readily be granted, though the proposition is by no means a mere truism, that if we are to have good architecture in England we must have a good national style; and it will also be granted that it is not necessary for such a style to have originated entirely at home—for by discarding all that can be traced to foreign sources we shall leave ourselves very few materials on which we can work. The questions we have to consider are these:—Have we at present any style of our own?—Are we likely to work out a new style from our own resources and from the materials we can command?—Ought we to endeavour rather to revive some ancient style; and if so, in which of those before us are we most likely to be successful? I assume of course that we are desirous of establishing a style applicable to all our purposes, capable of combinations of the highest beauty and grandeur, and opening a sufficient field to the genius of the architect, as well as to that of the sculptor, painter, and other artists who may contribute to the perfection of his work.

I am not sure whether we are not apt to draw too nice a distinction between building and architecture, and to take away from the province of the latter such works as our ordinary dwelling-houses, cottages, street fronts, and the like, unless they claim a title to it by adopting the most prominent features of some ancient or mediæval style. But, in truth, every structure is architectural which shows that thought, care, and skill have been bestowed upon its appearance. A very small amount of ornamental detail, if it be well designed or well chosen, and well applied, will often be sufficient to represent as it were a more elaborate system; while a careful study of forms and proportions, even if there be no ornament whatever, according to the common acceptation of the word, may give a building a high place among architectural compositions; and therefore I said it was no truism to assume a good national style to be necessary, if we would have good national architecture. For a building may be architecturally good, and yet have no feature which decidedly marks it as belonging to some recognised style, or the adoption of which would originate a new style. But though a few examples of this description may be imagined, and some perhaps are actually to be found, it is not likely that the taste of architects, unguided by rules, should concur in the production of such buildings throughout the land.

We must have cheap buildings—of churches I shall presently speak more at large—but we must have public buildings of various kinds, as well as private, the erection of which shall involve little or no unnecessary outlay; whose adornment or adaptation to style shall form a very insignificant item in the cost, compared with what is absolutely necessary to insure good work, convenient arrangement, and sound and durable construction.

Now if there be any style or manner in which these buildings are generally designed, or have been so long as anything like unity of purpose prevailed, are we to consider it, so far as it goes, to be the national style, with the power of adding such a system of ornament, whether invented or borrowed from foreign or bygone styles, as shall best harmonise with its own principles of construction and composition; so that between buildings of the highest and humblest class there shall be a certain relationship and unity?—or ought we to have one style for our ordinary buildings, and another for works (to use the expression of our neighbours) of a monumental character? And again, does our ordinary or vernacular architecture belong to or readily assimilate with any recognised style, so that the ornaments, general forms, rules, and principles of that style may be adopted and engrafted upon it, without changing its character or rendering it less fit for its purposes?

With regard to the first of these questions,—it strikes me that any essential incongruity between our vernacular and monumental styles would be productive of great inconvenience, and probably offer a serious obstacle to the advancement of either. For a large class of buildings, public and private, will necessarily occupy a place between the two, being neither merely vernacular nor yet altogether monumental. And it is on these that the character and aspect of our great towns will depend. In such buildings something more may be allowed to ornament than in those of the simplest and cheapest class; and yet considerations of economy must not be altogether thrown aside. If there be that congruity between the highest and lowest class which makes their difference to consist in degree rather than in principle, then the architect of the middle class has merely to apportion to circumstances his amount of expenditure in ornament. There is no actual line or barrier by which he must be decidedly controlled, or which he must decidedly overleap, so as to attach his work to one or other of two distinct classes, the vernacular and the monumental. But if there be a manifest break between the two—a clear line of demarcation, on one side or other of which the architect must take his stand, is it not likely that the result will often be, on the one hand pretension, extravagance, and the sacrifice of convenience to show? or on the other hand, if the lower side of the barrier be taken, neglect and indifference on the part of the architect, as if his employment were beneath his care and consideration?

We must inquire, then, if there be any style which we may call our own, perfectly suited to the wants of the present day; expressive, or capable of being made expressive, of the spirit of the age; and sufficiently comprehensive to embrace both vernacular and monumental works, and that large class which partakes of both characters. If we would view the matter in its proper light we must go back somewhat more than a century. So many of our cheaper structures are of an ephemeral character, and so many of our more expensive ones are built according to the fancy of the architect or his employer, that they cannot be said to represent any national or permanent style whatever. But if we look at several domestic structures, whether insulated mansions or forming parts of streets, of about the date of Queen Anne's reign, we may find something not at all unworthy to be taken as a national style; combining many artistic qualities of no mean order, with dignity, durability, and convenience. There is a house of about the period of which I speak at the entrance of Camberwell, which I never pass without being struck with the beauty of its composition. It owes little or none of this beauty to ornament, for nothing can be plainer or more simple in this respect. Owing however to its detached position, it admits of a ground plan more favourable to variety of outline and a play of light and shade than can usually be obtained in houses forming part of a street. But both in the metropolis and in country towns, we see houses which may be referred to the same type or style of architecture, more or less enriched, which give no small degree of grandeur, and some picturesqueness, to some of our street views. The style, it is true, became unpopular when a more formal imitation of the Greek models was affected; and still more so when, as a natural consequence of this depressing formality, Classic architecture became less in fashion, and the fancy for Mediæval architecture began to prevail. Many fine specimens were consequently pulled down to make way for structures of more pretension, but less real merit—as, for instance, the School at Birmingham: but this is no proof that the style is unsuited to the spirit of the age, or of the English nation, and that it might not with advantage again occupy the position of a national style. To go no further, it harmonises with the character of the houses we build when we work without reference to style, and are guided solely by the consideration of our own requirements, the state of society, climate, and material.

If there be any fitting system of ornament by which such houses may be enriched, without sacrifice of convenience and adaptation to purpose, and at the same time sanctioned by antiquity or some recognised school of art, and therefore capable of being carried out according to certain rules, such system may be worked into our national style; and, supposing it has already been applied, it has then become a part of our national style, no matter from what quarter it may have been derived—provided that the buildings on which we have engrafted it be what we should naturally design with a view to our convenience, and that the style itself or system of ornament be conformable with the spirit of the age, and with its advancement in art, science, and general characteristics of civilisation. I believe this is the only legitimate sense of the term "revival," as applied to an ancient style. For revival does not consist in the mere reproduction of forms or decorations, which may at any time be obtained by a clever copyist; nor even in the occasional appearance of a work conceived in the true spirit of the period which its architect intended to represent, such as the kitchen at Alnwick Castle, designed by Mr. Salvin, a truly original composition, and one which will bear comparison with any corresponding work of the best Mediæval period;—but in the establishment of the style in such a manner that it shall be universally and I may say instinctively employed; that it shall not only admit of, but actually suggest, such modifications as circumstances may demand; that it shall never appear to be forced upon the ordinary or vernacular architecture, but rather to flow from it naturally and readily; that, so far from exhibiting any tendency to unfit a building for its proper purposes, it shall even seem to render its adaptation to them more complete; that, instead of constantly reminding us of its foreign or remote origin, it shall impress us with the feeling that it might be the growth of our own age and country (and this cannot be the case if it bears the stamp of a totally different era in the progress of refinement); and above all, it ought to convey the impression that it has been based on practical grounds, and is not the offspring of mere fancy or sentiment.

---

* Lecture delivered at the Architectural Exhibition.

We know that two styles are asserting rival claims to the architecture of the future. At present they seem to assume a hostile attitude towards each other, and show but little tendency to coalesce, though it is certain that any style likely to grow and flourish and mark the character of the age, must combine elements possessed by each. At the same time it is equally certain, that to secure that unity which is essential to the very life and existence of a national style, one of them must occupy a superior position, and the other take a subordinate one. These two styles are the Classic and the Gothic or Mediæval. We will give each the broadest definition; considering the Classic to comprehend the Grecian, which its scanty remains present to us under rather a severe if not monotonous aspect, though a careful study of them shows its artists to have been gifted with powers of imagination as vivid and fertile as those which have been developed in any era of human history,—the Roman, which combined the Greek with other elements,—and the revived Italian, which was introduced about the fifteenth century, and has more or less steadily held its ground ever since. The Mediæval style may be considered to have commenced on the decline of the Roman, in the fifth or sixth century, or earlier; and we may trace its principles through the Byzantine, Romanesque, Saxon, and Norman, till it culminates in that Pointed or Gothic style which sheds a lustre on the thirteenth, fourteenth, and fifteenth centuries.

With which then of these two styles does our vernacular architecture best harmonise? From which of them does it, with most propriety, borrow its decoration?

Let us suppose a house front, forming part of a street, to have two stories above the ground floor, each with four windows. This seems as likely an arrangement as any to suit general convenience. In the first place, we may pay attention to the proportions between the length and width of the windows, and to the breadth of the spaces which divide them. The probability is that we may satisfy the eye in this respect without the least sacrifice of comfort. As to the form of the window opening, there can be little doubt the rectangular is most convenient when woodwork is required, as it must be in dwelling-houses; and when the ceiling is flat and the height of the room limited, the contraction of breadth at the top which an arched window involves may cause an inconvenient diminution of light. But if stone lintels are not to be obtained, and brick or small stones are principally employed in construction, then the head of the window must be an arch. This ought not to form a perfectly horizontal line, both as being apt to sink, which produces an unpleasant effect, and as disguising the construction by giving an arch the form of a lintel. A decided curve should therefore be given; but the less it deviates from the straight line, the less will be the sacrifice of those advantages which belong to the rectangular form. A segmental arch comprising a very small arc of a circle is satisfactory to the eye, easily fitted up with woodwork, and unites the qualities of convenience and constructive truth. It is accordingly very commonly adopted, and is equally applicable to the palace, the mansion, and the cottage.

We have now obtained a front not unpleasant to the eye, but altogether devoid of ornament; although the care bestowed upon its proportions and arrangement entitles it to be classed as an architectural composition. How are we to begin if we want to enrich it? There is probably nothing in the internal arrangement to suggest a division by vertical lines, for the partitions between the several rooms may be arbitrary and irregular. The real lines of the building must be horizontal, as it is evidently divided by ceilings and floors into several stages. If the position of these be marked by good and effective string-courses, and the whole crowned by a rich cornice, we are at once in possession of a meaning and telling system of ornament, which will give the front an air of considerable richness, even if we go no further. As the Classical style is that in which the horizontal line predominates, we shall naturally be led to look to it for examples of such cornices and string-courses as we require; and we shall find that it furnishes them abundantly, presenting us with specimens which, for clearness, brilliancy of effect, and the suggestion of constructive truth, are altogether unrivalled. The Roman mouldings, as applied to horizontal lines, form a most valuable study, and have perhaps more of effectiveness and variety than the Greek, besides being more generally applicable in a style where the Greek element is so much modified by the introduction of others.

But the vertical line, though subordinate, need not be left wholly unrepresented. The termination of the building, where it joins the adjacent houses, may be marked by some kind of pilaster coigning. The windows, ranged one immediately over the other, leave vertical stripes, which may also be marked by pilasters of small projection in one or more of the stages. The addition of these is right in a constructive point of view, for they give the wall some apparent and a little real additional strength where the superstructure is heaviest. And although the introduction of these pilasters may seem a step in the direction of Gothic, which exhibits the predominance of the vertical line so as to carry out the principle to the verge of exaggeration, yet it is not at variance with the spirit of Classic architecture, in which indeed the same principle has sometimes been expressed a little too prominently. The frequent use of the engaged column is perhaps one of the least defensible features in the Classic, both ancient and revived.

Should the engaged column be discarded, or used very sparingly, it becomes a question whether we ought also to discard those parts of the pilaster which give it the air of a substitute for the column—namely, its base and capital—so leaving it as a mere vertical strip. I can hardly think we are called upon to make the sacrifice. If the pilaster preserve or represent the proportion of a Classical column (for we must look upon the column not only as a mechanical support, but also as an expression of true proportion, and a kind of modulus for the measurement of the whole building), then it cannot be wrong to preserve those features which are necessarily included when proportion is considered. And so far as they give the idea of vertical support they cannot be wrong, since the pilaster does actually add to the strength by which the superstructure is upheld. But where the arrangement does not admit of the columnar proportion and the full development of the entablature, or where the object is rather abutment than vertical support, regular base and capital had better be omitted.

Again, the edges of the window jambs might have some simple moulding of a durable character, or the windows may be furnished with dressings, by which an effect of depth is obtained. Further, it may be desirable to have projecting window-sills, wide enough to hold flower-pots and the like. These will give an additional scope for enrichment in the brackets which support them; and the more so as, the weight being small, such brackets may be designed with a view rather to elegance than strength. Those in similar positions—namely, under projections of no great weight, present some of the most beautiful curves that we find in the Roman as well as in the revived Classic. A hood, supported in the same manner, may be placed above the window, giving it some slight protection from rain. In buildings of a more ornate character the hood may be connected with the window-sill by small detached columns or engaged pilasters. A balcony might also be attached to a window opening to the floor of the room; this will rest on brackets of an apparent as well as real strength, proportioned to the increased weight. And a balustrade of stone, wood, or metal may be made to add to the beauty and character of the design. These projections give great life and picturesque character to street views in many Continental towns.

Now here we have arrived at a front of considerable richness, and altogether falling naturally into the style of the revived Italian, which will also furnish us with the means of introducing panels of sculpture, or discs of marble, into such parts of the surface as may still be considered by the architect or his employer to be too deficient in ornament. In all this, you will observe, there is no straining at effect; no going out of the way to meet the exigencies of a style; no sacrifice whatever of convenience;—the scale of magnificence, and consequently of expense, may almost be regulated to a nicety; every addition offers itself in a direct, straightforward manner; and the result, to an unprejudiced eye, will be satisfactory if the composition be worked out with judgment. Of course, a bad architect could out of the above materials produce something very tame and meagre—for there never has been, and never will be, a style the mere adoption of which will be sufficient to insure excellence; but I am convinced a good architect would bring out a design full of grace and vigour, and, however commonplace its elements, give it the stamp of originality.

Undoubtedly it is possible to Gothicise, in a manner, such a street front as I have imagined. We may divide it into bays of one or more windows, and mark the division by buttresses or strongly predominating lines. We may choke the windows up by mullions and tracery, and give them pointed heads; or we may retain the square-headed or slightly segmental window without mullions, placing over it a Gothic arch against the blank wall, so as to cut the floor-line of the apartment above. But neither these, nor any other devices by which modern requirements are made to conform to Mediæval architecture, are suggested by the simple primitive arrangement, nor do they show any congruity with it: indeed, it requires some exercise of skill and contrivance to prevent Gothic details from interfering with the comfort of an arrangement which is really Italian.

Had I chosen for my illustration a front of five or seven windows instead of four, the door would probably have occupied the centre of the ground stage; and the building, arranged symmetrically on each side, might naturally have suggested a Classic rather than a Gothic treatment. The number of houses without much architectural pretension that are so arranged, presenting a symmetrical front, and for whose decorations the architect has instinctively turned to the Classic style, shows that the arrangement cannot be otherwise than generally convenient; but by choosing a composition that does not form itself symmetrically, the door being placed nearer to one side than the other, I would show that the employment of the Classical style does not tie us down to so strict an observance of regularity as to involve any sacrifice in point of convenience. It is true that glaringly needless irregularities are offensive, perhaps more so in Classic than in Gothic; and in most cases it is the part of the architect to combine regularity with convenience: the problem is generally one that can be solved in a satisfactory manner; but where it cannot, as in the case we have been considering, the want of symmetrical regularity is felt to be no defect. An utter disregard of symmetry is not to be tolerated in any architectural composition, be it Gothic or Classic; though an occasional interference with it—whether it be accidental, as when it results from the incomplete carrying out of a design, partial ruin, or change of architects; or whether it be owing to the exigencies of the building—often gives life and picturesqueness to a composition; and there are many incomplete and irregular fronts—such for instance as that of Rouen Cathedral—which we should be sorry to see reduced to a formal symmetry. But if we build for the picturesque we must be careful that our aim be not too apparent; for irregularity ceases to possess the charm of picturesqueness the moment it ceases to appear accidental or forced upon us by circumstances.

We have now to consider the question whether we ought to have two distinct and dissimilar styles—one for secular, the other for ecclesiastical purposes. And here I think the advocates of the Gothic revival have taken a more advantageous stand than those who oppose its application to secular purposes: for the latter seem not unwilling to relinquish the Classic style in church building, so long as they retain it for civil uses; while the former contend that the Gothic is the best, not only for churches, but for all structures whatever. In fact, they evidently feel how necessary is unison in a national style. I must confess that, if they can establish Gothic as the only legitimate church architecture of the present day, I do not see how their opponents can long resist their claim upon secular architecture also. Churches must be classed among what we have referred to as monumental buildings; and it is clearly adverse to the progress of art that the architect should have to give up his mind to two sorts of composition, both of them of a high order, grounded on principles that in many respects are antagonistic to each other. The dissonance between buildings of different styles, like the irregularities in the same building that I have just spoken of, if they are clearly the result of accident or necessity, as when they actually belong to different periods, is valuable, both as conducive to picturesqueness and as forming a sort of historical record; but when it is no other than the result of caprice, waywardness of fancy, or want of unity among artists, it becomes unpleasing to the eye, and perplexing to the mind. Nor can it be said that it is necessary to have one style for houses or secular buildings, and another for churches, in order that we may know a church when we see it. Of the thousands of churches that have been built at different times, whatever may be their style or date, how few are there that would be confounded with secular buildings, and *vice versâ*.

The ecclesiastical character depends very little indeed upon style; and it would be possible to build a church, perfectly unexceptionable in composition, form, aspect, expression, and general arrangement, without introducing any one characteristic of any recognised style whatever.

As an instance I will notice a Protestant church at Emmerich, near the Dutch frontier, on the Rhine. In date it corresponds with that period to which I have referred as offering something like a national architecture of our own—namely, the reign of Queen Anne. It is of brick, very plain, and devoid of ornament, and worked in rather a meagre manner, the walls being evidently very thin. The plan is a Greek cross with very short arms, and no arches across the intersection, which might support a central tower or dome; the whole roofing is consequently of wood. This is high pitched and hipped; only one of the fronts having a low pediment, which had better have been omitted: a wooden cupola or lantern, of a very ordinary description, crowns the top. The windows are round-arched, and arranged in two tiers for the sake of galleries. There is but little detail anywhere: what there is has a Classical character. Now I doubt not that an exclusive admirer of Gothic would pronounce this an extremely ugly building, and would wonder what made me stop in the town an hour for the purpose of examining it; but I confess I was very much struck both with its appearance and capabilities. From a distance I saw not only that it was a church, but a very good church; nor was I disappointed on a nearer approach, when I could judge better of its proportion. Had the walls been thicker, so as to give more depth and effect to the openings, I should have considered it really a grand building. There is a church of much the same form, and probably date, at Eisenach, in Germany, having however square instead of round headed windows, which do not detract from its ecclesiastical aspect.

Another church which I may here notice is one at the Hague, which also has high-pitched timber roofs, and a central turret of the same material. The plan of this church comprehends two intersections by transepts, which, as well as the ends, are apsidal. Externally the style is Classical, having large pilasters with regular capitals and entablature; internally there are no details belonging to any style, though the open timber roof gives an appearance of richness. It is decidedly a striking object, and well worthy of study. I should think it not impossible to give it a construction which might admit of a stone central lantern or turret. But even our own Dissenting chapels of the last century and the beginning of the present, plain and often tasteless as they are, have a certain character which marks them as set apart for religious purposes; and without being different in style (if they can be said to have any) from the houses on each side of them, are easily distinguishable, and leave no doubt with the spectator as to the purpose for which they have been erected. I must however rescue from the charge of tastelessness one at York, built I suppose about the middle of last century, and just as devoid of any pretension to style as the plainest of the houses which surround it. It is nearly in the form of a Greek cross, and has a wide and low central tower, giving the building an outline not inferior in dignity to many good Mediæval churches.

If it were not for the existence of structures which we are not likely again to require or reproduce—I mean cathedrals of the largest class—I doubt whether the Gothic movement would have proceeded with much spirit, even if it had been commenced at all. It is only by such structures that we can be impressed with a full admiration of the style; and any argument in favour of its revival which rests on the impressiveness of such buildings, falls to the ground if it can be shown that such impressiveness is what we shall probably never again obtain, at least by similar means. If this were a cathedral-building age it might be an age in which Gothic architecture could be revived. But it is not a cathedral-building age. We may require and build large churches—we may not grudge handsome and expensive ones—we may increase the number and force of choral establishments; but that pile of building which constituted the great cathedral of the middle ages, whose exterior expressed dominion over the adjacent district, whose interior suggested the idea of infinity—this we are not likely again to call into existence; not because we are as a nation wanting in the spirit of liberality, for large sums are continually expended in the restoration of our old cathedrals—and if one were to be utterly destroyed, I believe it would be rebuilt upon the same scale of magnificence;—but because we are a practical nation, and feel that cathedral building in these days is not the only way, nor the most effective way, of securing and spreading abroad the blessings of our religion—that an almost unlimited expenditure in mere externals (for cathedral building amounts to this), however it might have been justified in some epochs of the church, is not so in the present, when other necessities and exigencies call for a different application of our means. It is, I suspect, because this is not a cathedral-building age (for this practical spirit is not confined to our own country and our own persuasion) that our genius seems to flag and languish when we attempt what is specially the architecture of cathedrals; while in our engineering works we display a power, and, I will add, a perception of architectural propriety, not surpassed in the greatest works of the Romans.

◆

ON A NEW SAFETY COUPLING FOR RAILWAY WAGGONS.*

By Charles Markham.

It is remarkable that, notwithstanding the numerous improvements which have been made in all kinds of machinery during the last twenty years, some simpler mechanical contrivance has not been introduced to supersede the present rude and dangerous method of coupling railway waggons. Numerous attempts have been made at different times to accomplish this desirable object, but they have been abandoned in consequence of being found defective in working.

In the early period of railways, when the different lines were isolated one from another, the centres and heights of the waggon buffers were considered to be of little importance, and each railway adopted some dimension of its own. When however it became evident that, for the accommodation of the traffic, waggon stock of the same gauge must circulate from one end of the country to the other, uniformity in the centres and heights of the buffers became necessary. Resolutions were consequently agreed upon at the clearing-house that the height from the rails to the centre of the buffers should be 3 ft. 3 in., and the distance from centre to centre of the buffers, 5 ft. 8½ in.; the length of the buffers was fixed at 1 ft. 3 in. for dead or solid buffers, and 1 ft. 6 in. for spring buffers. These regulations have been in force for many years, and a considerable degree of uniformity now prevails in the general construction of railway plant, which materially tends to facilitate the introduction of a coupling that can be connected to any modern description of waggon.

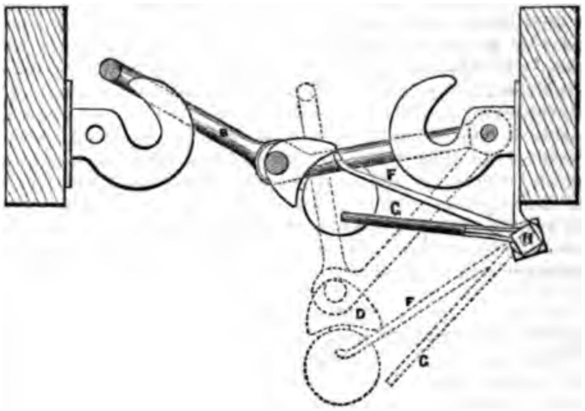
No class of railway servants are subjected to so dangerous an occupation as "shunters," who are employed in marshalling and forming goods and mineral trains, and are continually coupling and uncoupling waggons, frequently whilst in motion; this they generally accomplish by leaning on the buffers, and lifting the coupling link on or off the drawhook. If the buffers are compressed together when the engine starts and pulls the waggons forward, or if the engine-driver misunderstands the signals and suddenly checks the engine when pushing, the shunter is liable to fall in between the buffers on to the rails, and be crushed or mutilated by the waggons passing over him; and fatal accidents from this cause are very numerous.

The writer has now the pleasure of bringing before the meeting a new Safety Coupling for Railway Waggons, the invention of which is due to Thomas Osborne, who has been employed for many years as a fitter on the Midland Railway. A model of the coupling was shown to the writer by him about two years ago, but the invention at that period was in a crude and imperfect form; and as the coupling operation had still to be performed by the men going in between the buffers, the plan was considered to be of no practical value. With the assistance however of Mr. Harland, chief foreman of the Midland Railway carriage shops at Derby, the present plan of this coupling has been matured so that it can be successfully employed.

Fig. 1 shows the process of coupling; Fig. 2 is a side elevation, and Fig. 3 a plan of the coupling. The coupling consists of a straight double link AA, Figs. 2 and 3, connected at one end by a pin to each side of the shank of the drawhook, whilst the outer ends are connected to the coupling link B by means of the pin C. This pin has a projection or tripping catch D, forged upon it in the middle, and its ends are flattened and fit into corresponding holes in the coupling link B, as shown in Fig. 2, so as not to turn in it. The coupling link has its straight ends prolonged backwards beyond the pin for carrying the counterbalance weights E, which serve to keep it in its proper position for being acted upon by the lifting lever when the operation of coupling is to be performed. The lifting lever F is worked from either side of the waggon by handles G, on the ends of the transverse shaft H, Fig. 1, which is carried in hangers from the sole bar of the waggon. Each waggon has a similar coupling at each end if desired; and when two waggons are coupled together, the link which is out of use remains suspended in a vertical position.

In coupling the waggons together by this apparatus, the lifting lever F is raised by the handle G, and bears against the nose of the tripping catch D, as shown dotted in Fig. 1; thereby raising the link B, until it obtains a bearing on the underside of the catch, when it throws out the coupling link B, which is thus brought over the opposite drawhook, and is then allowed to drop on the hook by lowering the lever. In order to uncouple the waggons, the link is first raised by the lever till it is disengaged from the drawhook, and is continued to be raised still further until the nose of the tripping catch escapes the end of the lever, when the coupling link is tipped up by the counterbalance weights E, into a vertical position, and is then lowered by the lever, clear of the drawhook, into its original suspended position. A stop I, Figs. 2 and 3, is provided inside the coupling link B, which comes against the side link A, to prevent the coupling link tipping over too far back.

Fig. 1.



The mechanical success of the plan now described for coupling railway waggons is due to the introduction of the elbow joint and tripping catch in the middle of the coupling, whereby the coupling link is enabled to pass up clear of the opposite drawhook in lifting, and is then extended forwards to reach over the hook for coupling the waggons; while in uncoupling it is first disengaged from the hook and lifted up, and then swings free into a vertical position, so as to drop clear of the hook in lowering. The advantages attained in this plan are—safety to the men, dispatch in the process of coupling and uncoupling, and cer-

Fig. 2.

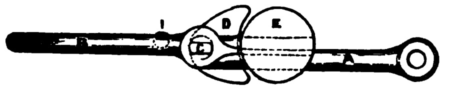
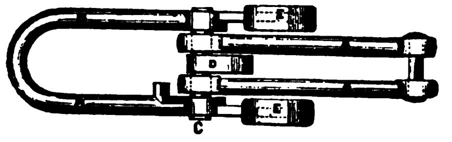


Fig. 3.



---

* From a paper read at the Institution of Mechanical Engineers.

tainty of action. The coupling consists of few working parts, and these are not liable to derangement in the ordinary working of railway waggons; but even in the event of the lifting lever accidentally getting out of order, the coupling can be made use of as an ordinary coupling by being lifted on or off the drawhook by hand. The coupling can be applied to any waggon with the same facility as an ordinary coupling, with the exception of the extra cost of labour and material for the levers for working it; it can also be easily coupled to another waggon, even though there should be a difference of 6 inches in the length of the buffers. The difficulty of coupling waggons together on a sharp curve, in consequence of their being out of line with one another, has been provided for by widening the opening of the coupling link B, and lengthening the centre pin C, as shown in the plan, Fig. 3, so that the link has a sufficient opening to insure its always engaging the opposite drawhook, even on a sharp curve; while the side links AA of the coupling are kept straight, to withstand the violent jerks which all waggon couplings are subjected to.

For testing the efficiency of this coupling a waggon fitted with it was attached to the shunting engines that are employed in sorting and marshalling trains at the Derby station, and was kept constantly at work both night and day for about two months; the very heavy trains that had to be shunted, and the great variety of waggon stock that passed through the station in transit to different parts of the country, afforded an excellent opportunity of detecting any defects that might exist in its application. The result of this trial showed that nearly the whole of the waggon stock on the Midland Railway, including upwards of 17,000 waggons belonging to colliery proprietors and others connected with the coal trade, could be coupled or uncoupled with the greatest facility by means of the new coupling. The variation in length of the buffers of the different waggons now in ordinary use, and running in connection with the Midland Railway, does not exceed 6 inches; and there does not therefore appear to be the slightest objection to the universal application of this mode of coupling to all such waggons. Some waggons however of an old make, belonging to the London and North Western, and Manchester, Sheffield and Lincolnshire Railways, have no drawhooks; consequently in such cases the men must couple the waggons in the ordinary method; but these cases are the exception to the general rule, and in a few years will be entirely removed by the substitution of an improved description of waggon stock constructed in conformity with the general regulations of the clearing-house.

The principal impediment to the immediate introduction of the new safety coupling, will be its extra cost as compared with the ordinary coupling, the cost of each plan being as follows:—

Ordinary Coupling.	*s.*	*d.*
35¼ lb. of iron at 1⅛*d.* per lb.	3	4
Labour	0	8
Total ...	4	0
New Coupling.	*s.*	*d.*
46 lb. of iron for coupling, at 1⅛*d.* per lb.	4	4
Labour	5	5
18 lb. of cast-iron for balance weights, at 7*s.* 9*d.* per cwt. ...	1	2
Labour	0	5
51 lb. of iron for lifting lever, shaft, hangers, &c. at 1⅛*d.* per lb.	4	9
Labour	4	7
Total ...	20	8

The extra cost of the new coupling is thus 16*s.* 8*d.* for each coupling, or £1 13*s.* 4*d.* for both ends of the waggon.

There does not appear to be any doubt respecting the successful application of the new coupling in its present form: but the writer thinks it may be advisable to increase still further the size of the rods, levers, and pins, since they may possibly be found too light as at present made; for experience has shown the necessity of making every description of rolling stock strong enough to withstand the violent concussions it is liable to.

Mr. Markham showed a full size working specimen of the coupling in action, which could be altered to allow of 6 inches variation in the distance between the drawhooks, for exhibiting the range of action of the coupling. He observed that a previous attempt had been made at a mechanical coupling to supersede the present mode of coupling by hand, the coupling link being lifted by a lever from the side of the waggon, but the link was made in a single length without a joint, and would therefore only work with a uniform length of buffers, and if the buffers were at all short the link did not drop into the drawhook till the waggon was started. In the new coupling however the principal element of success was the elbow joint in the middle, which enabled the coupling link to reach over the drawhook even with the extreme variation that was met with in length of buffers, amounting to as much as 6 inches. With the present mode of coupling by hand the loss of life was fearfully great, and the accidents were extremely numerous, far more so than was generally known; it was therefore of the greatest importance to prevent the continuance of such accidents by the adoption of some such mechanical coupling as that now described. There were about eight sets of the couplings now in use on the Midland Railway, and one had recently been put to work on the Manchester, Sheffield, and Lincolnshire Railway.

Mr. J. Wright fully concurred in the importance of adopting some mechanical mode of coupling to prevent the loss of life and accidents occurring under the ordinary mode, which to his own knowledge were lamentably extensive. He had not yet seen the new coupling in operation, and hoped a thorough trial would be made of it on several railways, in order to test its working under a variety of circumstances. The coupling appeared a good deal heavier and more costly than the ordinary couplings, and he thought it would be a great advantage if it could be somewhat simplified; for a chief source of expense in waggon repairs was the loss of the couplings, which were generally broken off at the pin, so that the whole coupling was lost; and if any of the new couplings were lost they would entail a great expense for renewal.

The Chairman (Mr. Henry Maudslay) observed that the first cost of the new coupling must be considered in connection with its durability, and as a means of saving accidents and loss of life it deserved the best attention of all railways, and he hoped it would have a careful trial.

◆

ON THE RESTORATION OF ANCIENT BUILDINGS.*

By G. E. Street, F.R.I.B.A.

This subject is one on which it may be difficult to say anything absolutely new or original, and on which nevertheless it is of no little consequence that from time to time something should be said by those who feel the whole importance of the charge with which we are entrusted in the restoration of our ancient buildings. How is it possible to overstate their value? They illustrate almost every page of the history of our country, in letters which are legible and unmistakable to all who take the pains to read them; and yet the slightest mistake in the restoration of any one of them may go far to destroy all their interest and all their value. They connect the present with the past in the liveliest way we can imagine, yet a mistaken mode of restoration may end in leaving us nought of the old work or the old associations, but in their place a completely modern-looking building, with associations going no further than a tribe of modern workmen, a careless architect, and a committee of enthusiastic but ignorant restorers. So that, in truth, the restoration of ancient buildings may very easily—as it does, only too often—mean their *destruction.*

Our first duty is to be as justly conservative as possible whereever we have to deal with anything old. Not conservative in the sense of putting up a new copy of an old work—such as is in progress at St. Mary Magdalene's, Taunton—but conservative in the much truer sense of keeping the old work in its old place, with its old tints, its old weather-stains and lichens, and even its old defects.

It is almost impossible to overrate the importance of this first and great condition of all tolerable restoration, and I confess that as I grow older and think more on the subject, I find myself even more and more impressed with its invariable truth. Some years ago, at one of the first architectural meetings I ever attended, I remember having heard a discussion on the restoration of churches, which was opened by one who, partly for the sake of argument, partly because there was a half-truth at least in his argument, maintained that the only true mode of restoration was the "destructive," as he called it; by which term he explained that he meant, that we ought to decide for ourselves which is the best style for our purposes, to make some one style our own, and then ruthlessly to pull down everything that disagrees with it: so that the choir of Lincoln, and the nave of Peterborough or Ely, not being in that perfect Middle-Pointed style in which alone he saw any perfection of design or completeness of purpose, were I suppose to be pulled down, until nothing should remain but old works of one date, and new works in imitation of them; or—to carry the argument to its legitimate end—so that everywhere old buildings should give way to the perfect style (whatever that may be) of the nineteenth century. Absurd and extravagant as such a view is, there is nevertheless a vein of truth in it, for the argument was founded no doubt upon a careful consideration of the mode of work adopted by our forefathers, and in exact imitation of their mode of thought and action. No one who has examined their work can forget how little they reverenced the work of their forefathers. We praise William of Wykeham for his grand nave at Winchester, but what should we say to the man in our own age who should propose to continue the style of the central octagon of Ely on into the nave, by paring, destroying, or casing the old columns, inserting pointed and moulded arches, and throwing the aisle and triforium into one by the destruction of the Norman vault between them? Yet this is precisely what Wykeham did at Winchester; whilst his predecessor, Edington, no doubt pulled down a grand Norman west front in order to substitute his own conception in its place. And the instance I have given is one of all but universal application—every man in the middle ages seems to have thought his own work better than that of his predecessor; and the instances are rare in the extreme where, as in the naves of Westminster Abbey and Worcester Cathedral, the architect has distinctly copied the work of the earlier architect of the choir. And unquestionably, great part of the admiration we feel for this old work is intimately dependent upon that hardihood and self-confidence which ever characterised its designers; for it needs not to be said that, if our old architects had reverenced their fathers' works as much as we respect theirs, we should have had, perhaps, more buildings of uniform character, but they would have shown far less originality, and life, and vigour, than they now do. The reason however for this contempt for their predecessors' work is very plain, when we consider how comparatively short the interval was which separated the latest of our Mediæval architects from the earliest, and how completely it had been bridged over by the very gradual nature of the development in their style.

---

* From a lecture delivered at the Architectural Exhibition.

The destructive system of restoration which was the rule in the middle ages, however defensible and right it may be in theory, is entirely indefensible and wrong in practice. For let us once allow it to be right in practice, and we shall soon find men on all sides with little reverence for what has gone before, and much conceit in their own cleverness, ruining in a short space of time that which no space of time whatever can give back to us. There are three modes of destructive restoration, and each equally effectual. The first, that which would pull down and reconstruct in a new style; the second, that which would pull down and re-erect in the same style; and the third, that which would tool and scrape every stone in a wall until the whole should appear to be new. Of these systems the largest and boldest examples are, fortunately for us, to be seen on the Continent, and we have suffered comparatively little as yet. (The lecturer, after commenting upon the destructive system of restoration pursued upon the Continent, then proceeded—)

How much is lost in the course of destructive restorations it is almost impossible to calculate. In some cases in England we have suffered terribly, and nowhere more than at Salisbury. The destruction of the old campanile, the confounding together of portions of monuments of various dates in the most indiscriminate fashion, the removal of screens, and the carting away of old stained glass to the city ditch. are among the architectural sins for which James Wyatt, "the destructive," as Pugin rightly called him, has to answer.

The restoration of the west front of Lichfield Cathedral between A.D. 1788 and 1795—one of the most abominable even of the works of that "ingenious architect Mr. James Wyatt," as Storer called him—and the restoration of St. Denis, in France, are cases of even more grievous spoliation than that of Salisbury; and we cannot, I think, be too thankful that an age in which all restoration would necessarily have been destructive in the extreme, was at the same time an age of such apathy and lethargy, that it was the rarest thing for any restoration or repair of an old building to be undertaken at all.

That third kind of destructive restoration to which I referred is unfortunately so popular with some people, that if we do not take care great damage will be done, not always to the architectural design, but (which is just as important) to the colour, tone, and interest, of our old buildings. And in reference to this I am unable to avoid mention of two restorations now or lately in progress, both of which seem to me to be of an unfortunate description. They are those of the western fronts of Lincoln and of Winchester. The former is, I am told, being re-tooled and repaired wherever defective, so as to make it look like a new work of our own day. And the history of the whole thing is worth telling. It seems that a former clerk of the works is supposed to have had some interest in the use of a Yorkshire stone in place of the native stone in repairing the west front. The Yorkshire stone he used has decayed rapidly, and all his work now requires renewing with the same stone that was used in the old work; but not content with repairing defects, they are carrying the cleaning, tooling, scraping process over the whole of the work, so as to make it look uniform. I wish men would consider a little what this cleaning process involves. Directly you set a mason to clean a piece of old work, he proceeds to chisel away something like an eighth of an inch of the surface everywhere. All mouldings assume, of course, new proportions: the hollows become larger, the bowtells smaller, and each cleaning is therefore one step in the destruction of the work; whilst it happens continually that an ignorant workman, will in an hour or two, destroy the special features of an old moulding, without having the slightest idea that he has altered the section at all. It ought to be understood, therefore, that in all cases of cleaning and refacing old carved or moulded work, no amount of skill on the part of the architect (who cannot always be on the spot) can secure the work from irreparable injury; and I hardly know what guarantee we can have that at Lincoln the damage to old colour, and the alteration of the relative proportions of mouldings, are the only things we shall have to lament in this mistaken work of so-called "restoration."

At Winchester a most inexplicable work of the same kind is in progress. Here the main beauty of the old work was its colour. It never was a very grand façade, and had many of the usual faults without the best features of Perpendicular design; but time had done its work, and the west front was in colour and general effect fairly in harmony with the rest of the building, and a work for Englishmen to be proud of. Now, as you go along the railway to Southampton, you see the new tower and spire of a church, and beyond it what seem to be the equally new gable and pinnacles to the cathedral; and I hear that they propose to polish up the whole west front in the same way, to match the gable; then, if funds last, I don't see why they should not undertake the side walls, and finish up with a refresher over the whole surface of the fine Romanesque central steeple! When all this is happily consummated, the good people of Winchester will, I suppose, be happy, and their grandchildren may hope to see the cathedral again in its old colour and with its old effect. I cannot imagine that the stonework required scraping; for not only is the stone at Winchester generally in very fair condition, but at the same time I have but little doubt that the putting a new face on it will render its future decay more probable and rapid than any other course that could have been adopted. The castle, and much of the exterior of the cathedral, at Norwich, are also examples of destructive restoration; and here the walls have been so plastered with cement, coloured to imitate the stone in the most elaborate way, that I fear most of the original work is absolutely destroyed.

Destructive restoration is accomplished also by the removal of furniture or fittings of old buildings as often as by the alteration of old detail. For instance, there used some years since to be a number of very fine carved oak stall or desk ends, of the fourteenth century, in the choir of Wells Cathedral; their places are now occupied by new work and designs, and on a recent visit I could find no trace whatever of any of the old ends, whilst the verger absolutely refused to allow that there ever had been any such work as I described in the cathedral. Similarly, I remember seeing the fine wooden gates of the screen at Dorchester in a builder's yard at Oxford; copies of them having been erected in their place, to save the trouble of restoring the old gates, and probably without the knowledge of the architect. So, too, some one once sent as a present to the Oxford Architectural Society, a fine seat-end, which I recognised as having been taken from a church in Staffordshire, probably during some repairs; and in these cases we architects are by no means always in fault, for there are some clerical and other restorers who take strong fancies and strong dislikes. One man cannot tolerate his old chancel screen—another does not like poppy-heads; and each of them banishes his enemy when he has him in his power during the work of restoration! And then there are, or at any rate there have been, some antiquaries who seem to think it no theft to pocket a curiosity, and have no compunction about giving the last wrench at an old brass. So of late years the grand St. Maur brass at Higham Ferrers has suffered; and at the present moment, the church having been shut up unused for a couple of years, one of the older brasses is all but pulled off the stone, and will probably, unless more care than hitherto be taken, have disappeared altogether before the restoration is complete.

I was told the other day of a curious example of the effect of careless or ignorant restoration on the south doorway of the north wall of the choir of Lincoln Minster. The central shaft was of later date than the jambs, and the latter, having become decayed, have now been restored in imitation of the central shaft. The result of course is unfortunate in every way; and the story which the old doorway told has now a third chapter added, which makes the whole unintelligible.

So far all the examples of destructive restoration have been such as all will agree in condemning. There are other examples as to which we may well be more cautious in the expression of an opinion; because, though they are among the really destructive works, they are also among the best, the most careful, and the most sumptuous of restorations. Take the most remarkable example—the Chapter-house at Salisbury. Here we see the whole interior restored with new polished marble shafts; new stonework wherever the old was damaged in any way; walls and roof covered with new painting; and finally, the whole of the sculptures from Old Testament story which fill the spandrels of the arcades restored, repaired, and renewed in the most elaborate manner, and then covered with painting. Now, independently of the question whether the chapter-house be or be not now exactly in the state in which it was left in the fifteenth century (and, as far as the colouring is concerned, I doubt it vehemently), such an elaborate restoration is very dangerous. I believe it to be quite impossible, and very wrong, ever to attempt the restoration of sculpture. If you have a piece of old sculpture so damaged as to interfere seriously with the purpose of the portion of the building in which it occurs, the right thing to do is to move it bodily to some other place, and there carefully preserve it; whilst in its place you insert an entirely new and original work. You have no more moral right to touch up or patch the work on which an ancient sculptor bestowed his art, than you have to touch up, finish, and repaint the work of a Giotto or a Fra Angelico. They are all works of individual artists; and because their names happen to be unknown we are not relieved from the duty of preserving them exactly as they have been handed down to us.

In the Chapter-house at Salisbury no absolute necessity for the restoration of the sculpture existed. The old sculpture, damaged as it was, gave us nevertheless the exact measure of the artist's power, had all the interest which the certainty of antiquity imparts, and presented to us in every part the sculpture of the fifteenth century. Now it is difficult to know what to trust: the work has been done with singular care; yet I am confident that it must be impossible to repair and patch any old work without at the same time running great risk of having the old work chiselled, filed, and fitted to the new; whilst the final operation of painting has effectually concealed much of the delicacy of the sculptor's work. Suppose, for an instant, the same system adopted elsewhere, and our royal tombs at Westminster, our unsurpassed sculpture at Wells, our sculptures round the chapel at Ely, and elsewhere, all carefully and painfully repaired, restored, scraped, and repainted, and I think you will be affrighted at the idea. The truth is, that most of us at the present day had better, when we want to show our knowledge of sculpture, do so in our new work; and when we wish for colour, paint also our new works, and not our old. The question of the application of colour upon architectural work is not to be settled in a sentence; but, fond as I am of colour in its right place, I should generally dread very much to hear of its being applied to any old building for which I had much affection. Would any of us tolerate the idea of Westminster Abbey being given up to the colourist? I think not: for though the proportions, the mouldings, the traceries, would remain all as they were before; the marks of age, all that makes the church venerable or connects it to the eye with the associations of the past, would have disappeared at once; and we ought never to forget that in all restorations this evidence of antiquity is the one thing which, above all others, must never be destroyed on any account; and just as in all destructive restorations no account whatever is taken of it, so in all restorations well carried out this is the one thing which, above all others, is most taken into account. The first mode of restoration is fairly called Destructive; the second and safer mode is rightly called the Conservative—and I will now endeavour to show how this mode may without difficulty be generally carried out.

The mason must be attentively watched in his mode of doing his work: he should (if the old work be good) attempt, as far as possible, to assimilate his own to it in every way—in the bond of the masonry, in the mode of dressing or working the stones, and in the general character of the work. He should be allowed to indulge in no such ingenious devices for spoiling masonry as black mortar or ruled joints; and whether the work be new or restored, he should be compelled to do it at least as solidly and substantially in all respects as the old work.

Where old buildings are so decayed as to be capable of repair only by propping or by rebuilding, the former is generally the better of the two plans, as still leaving most of the old work intact. When rebuilding is decided upon, if the stone is not decayed, and the work very good in its character, every stone of the old work should be marked as it comes down, and should be re-erected in its old place, and with as little disturbance as possible to the old work. This is the true conservative course; but I am not sure that any good example can be given for the course (so often taken now) of rebuilding entirely new work in imitation of old work which has been completely destroyed. At Doncaster, for instance, after the fire it was made a great point that the steeple (I am not sure about the church) should be accurately restored in the new building. The architect's hands were tied by the condition, and he has given us a steeple and a church which are evidently compromises. They are not really a copy of the old work, and yet would probably have been still better than they are if they had not pretended at all to be a copy. At St. Mary Magdalene's, Taunton, the steeple is being rebuilt in exact conformity with the old work, and an enormous amount of architectural superintendence given to that which is after all only the proper work of an ordinarily intelligent clerk of the works. Finally, at Chichester, the central steeple is a ruin, and the people of Sussex have come forward nobly with a large part of the funds required for rebuilding it. But the first condition one hears is that the steeple is to be rebuilt as of old; and one asks with some astonishment whether it can really be purposed to erect a copy of the late spire upon the copy of the early tower! Surely it would be tenfold better, if copying there must be, to confine it to the tower, and to make the whole steeple uniform in its style. There ought to be no difficulty about making a spire at least as good in its outline as the old spire; and the rebuilding of an exact copy of it, with nothing but new materials, would not to my mind be a restoration at all. Nevertheless, the spirit which prompts this desire for exact fac-similes of old work is one full of good, and marks that intense love for our old buildings and old customs which still I hope marks the people of England above all others at the present day.

In matters of detail, conservative restoration is often possible when it is not practised. In stained glass, for instance, Mr. Ward some time ago gave an example of the best mode of restoration, in an old window of a church in Berkshire which I was restoring. A good deal of the glass had been destroyed: the leading still in the main remained; and he re-leaded the whole of the glass, filling in the vacant places with plain glass, opaquely painted; and the result was that, at a small expense, we had the old work, and nothing more, permanently preserved, with nothing conjectural, and with an effect which, I confess, I could scarcely have anticipated. This work was done under Mr. Winston's supervision.

There are many other points on which a restorer should take special pains to conform to the old example. Wherever old levels of floors can be discovered, they should be most carefully copied. Old levels are generally well arranged, and not unfrequently with great peculiarities. As, for instance, the laying a floor on a gradual slope up from west to east. Then again, the local fashion as to seats, &c. in churches, is generally preferable to any other, expecially where any example exists in the building under restoration which is at all worth repetition.

Painting on walls should, generally speaking, be carefully cleaned; and, where it consists of figures and subjects, should not be restored. If the work be rude, it can hardly be restored in a rude fashion without being absurd: if its character be good, then it is, as I have said elsewhere in reference to sculpture, a pity to touch it, lest we destroy any of the characteristic touches and fire of the old artist. I have the authority of Mr Layard—than whom no one has more zealously exerted himself in the cause of early Italian art—for saying that the greater portion of the damage which is done to the old Italian frescoes is inflicted by their restorers, who recklessly paint and repair every damaged work for which they can induce anyone to pay. And the fact is the more startling when we consider that the existing government of Italy is engaged in putting down the religious orders, turning them out of their houses, and converting the convents and churches—which contain the most glorious works of art in the world—into stables, barracks, and schools; so that the restorers must be actively vicious indeed who outdo such a government in destructiveness!

There is one common reproach in the mouths of those who have no feeling for our national antiquities, to which a few words of answer are necessary. They assert that all this work of restoration is unreal and untrue, inasmuch as both our religious life and our civil life are quite unlike what they were: they say that the old buildings of each class are consequently quite unfitted for our use on religious and on utilitarian grounds. In short, Lord Palmerston's "*Civis Romanus sum*" is interpreted literally by them, as it is by his lordship, to mean that Roman architecture is the only art fit for English citizens, and that we ought no longer to put up with any revival of English art. The charge is ingenious, but untrue. Take our churches—and in what respect is it necessary to alter them materially for modern use? As far as the Church is herself concerned, I may safely answer, hardly in any single respect need they be altered; for whilst Ely and Sherborne and a host of smaller restored churches show the perfect liberty which she enjoys and allows in their restoration on the most gorgeous scale, we hear now, week after week, of gatherings in our cathedral naves—either in Westminster or Exeter to hear sermons, or, as last week, at Ely and Peterborough to join in choral practice—so large that even their spacious areas are not ample enough to hold the crowds that throng through their doors. And is it possible that this English nation, which prides itself so much upon its practical character, should be so unpractical as to go on, year after year, ever more and more actively at work, restoring and refitting old churches, if those old churches are not the most convenient and the most suitable buildings that could be devised for their sacred purposes?

No work perhaps affords better training for an architect than the study which is involved in the attempt to become a thoroughly good restorer of ancient buildings. He cannot do his work even passably well without a hearty love and reverence for them; this love and reverence cannot be mere abstracting, but must be followed up by active work, active study, sketching, measuring, making notes, and thinking well upon and among them. This can never be done so well at any time as at first; and yet I grieve to say that a large majority of young architects go on year after year without apparently even so much as thinking of the necessity of studying old buildings for themselves, or taking the slightest active interest in any work beyond that which is put before them in their office. Now what must be the fate of buildings restored by a class such as this? Is it possible that they can be well, scientifically, or in any respect properly done? Obviously not. Yet—I am within the facts in what I say—I have over and over again had applications from assistants in want of employment, and it is a painful fact that a very large majority of them have never studied or sketched any old building; or if they have done so, have done it once or twice only in their lives, in a way so disgracefully careless as to make the hair stand on one's head at the idea of its being called study at all. Yet every one of them would undertake to restore a church with as much *sang froid* as it has been said one of our statesmen would display in taking the command of the Channel fleet. We want also educated clerks of works, and educated builders; and let me say, without any lack of respect for the class, that generally speaking it is much safer to intrust works of restoration to local builders in only a moderate way of business than to large contractors, who seldom themselves see the work which is being executed, and who do not find it worth their while to enter carefully into those minutiæ which every restorer of an old building is bound to attend to. Our educated architects must educate themselves, not in Continental examples or from Continental books, but from English examples and English books. Whatever may be the value of foreign study to the architect (and from some points of view it cannot be overrated), nothing is more certain than it will be of no help whatever in finding out the meaning or intention of ninety-nine out of every hundred of our old English churches and houses. They are thoroughly national, and all their peculiarities are national peculiarities. They have also provincial peculiarities, so that none can expect to understand them thoroughly without mastering all their provincial as well as their broader national peculiarities.

The Pugin Travelling Fund will, I hope, soon be in existence to encourage men in this branch of their studies; though, if the entire truth must be told, our art will not prosper while our students require a premium to induce them to study it. For myself, I should be ashamed of any young student of architecture who is content to waste his time and his holidays in indolent and selfish amusements, when he might, knapsack on back, be at work from day to day, for a month or two in every year at the least, walking from one spot to another of this glorious country; gathering as he goes the information which will enable him in time to distinguish himself in his art; while the act of obtaining it is as full of real pleasure as deer stalking, climbing Alps, or any other athletic work.

This, then, is the sum of what I have to urge: that only after diligent study of our old buildings should we ever venture upon undertaking the charge of their restoration; and that the great end and object of all our restorations should be to preserve the old fabrics in all their old beauty of colour and design, for our children's enjoyment. In our new works we have plenty of scope for the most ample originality, if we are capable of it. But we do not want to see Venetian Gothic windows introduced into our cathedrals or our castles, where they would be out of all harmony with everything that surrounds them, and standing evidences, not of our knowledge and our skill, but of our childish conceit and affectation of superiority to the men whose work we so obviously despise, though we pretend to restore it.

◆

INSTITUTION OF CIVIL ENGINEERS.

GEORGE P. BIDDER, Esq., President, in the Chair.

March 19 *and* 26, *and April* 9.—Discussion upon Mr. MURRAY's paper "*On the North Sea, with Remarks upon some of its Estuaries, Rivers, and Harbours.*"

In commencing the discussion it was remarked that the North Sea was one of deep interest, whether viewed commercially or geographically. The amount of shipping and the value of the commerce traversing that small sea were almost unparalleled. The approach to the Elbe in the winter season with north-west gales would be nearly impossible but for the situation of Heligoland, which enabled vessels to take a fresh departure for the mouth of that river. From the Naze to the North Cape the navigation was one of the safest in the world; for although the coast was rugged, it was intersected with harbours of unusual extent, in which ships could obtain refuge in all seasons, and during the most severe weather, in a very short time. Then again there were the variations in the range of the tides, which from Dover to the Thames amounted to from 18 to 20 feet, gradually diminishing to 5 or 6 feet on the coasts of Suffolk and Norfolk, and then rising again to 18 or 20 feet northwards. The tides upon the Danish and Norwegeian coast presented some singular phenomena. Currents were perpetually setting eastward from the Holmen Light up to the Skaw, varying in intensity according to the strength of the wind. The currents flowing into the Baltic were also subject to wind influences. In the narrow channels between Copenhagen and Kiel, traversing the Danish islands, the water was so fresh that the steamers using it had no occasion to blow out their boilers, and fresh-water fish had been met with in those channels. With regard to the fiords of Norway, the currents were entirely subservient to the winds, and sometimes change twice or thrice in the course of the day, the height of the water varying from 6 to 9 feet, according to the prevailing wind. It was thought, that without considerable currents the Dogger Bank could not be increased to the extent which had been predicted in the paper; and it was more than doubtful whether such currents existed, and where the material could come from to raise that large bank—equal in area to the principality of Wales—into an island.

It was observed, that along the Dutch coast from the Schelde to the Texel, there were two high-waters and two low-waters; the one proceeding from the southerly current of flood in the North Sea, and the other from the northerly current of flood through the Straits of Dover. The first was called the proper high-water, and was named by the Dutch the 'agger.' It was believed that there was no rise and fall of the tide on the Ameland Bank, or somewhere about 55° N. lat. and 5¼° E. long.; and that this might be accounted for by the fact of the two streams of flood, the one making from Flamborough Head to the mouth of the Elbe, and the other, which ran direct south along the Danish coast, meeting and neutralising each other at or about that point.

It was suggested, that at one time the North Sea and the Baltic were one sea, and that Holland, Hanover, Holstein, Jutland, and Denmark were in great part formed as a spit within this sea, so separating the Baltic from the North Sea. That the materials of which this spit was composed were derived from the encroachment of the sea upon the east coast of England, which must consequently have been of immensely greater extent, and very possibly towards the south united with the continent. That the oolitic cliffs to the north of and the chalk cliff off Flamborough Head, were the remains of a range of hills which must have at one period extended eastward. That the parallelism of the Dogger Bank and the White Bank with the granite chain across Scotland from Islay to Aberdeen, suggested this idea, that these banks were the remains of the abraded range of hills, and not an accumulation of sand as supposed by the author. That the encroachment of the sea which had been spoken of as taking place upon the coast of Holland, &c. seemed to prove that the action of the sea on the coast of England had resulted in a form of coast which prevented further rapid encroachment; and that the quantity of sand and *debris* now taken from the coast of Holland, &c. was larger than that carried to it from the coast of England. That the sand did not find its resting-place in the southern part of the North Sea, but was carried across the Jutland reef into the Sleeve, along which, as a marine river, it was carried round the coast of Norway into the ocean. That this nearly constant current was produced by the heaping up of the tidal-waters along the south coast of Norway and the west of Jutland. The absence of any rise and fall of the tide in those parts was accounted for by the continued accession of tidal waves to that part of the sea—first, the ordinary wave coming in between Scotland and Norway; followed by the constantly reflected wave from the coast of Scotland and England, which formed a curve of which the Naze was nearly the centre, as well as by the wave coming from Holland.

The study of the tides in the North Sea had been recommended, as likely to afford to a certain extent a key to the local tides in the friths, rivers, and harbours, with which engineers had to deal; and it had also been suggested that a contour map should be made of the bottom of the sea. Twenty years ago, when Mr. Scott Russell was pursuing his investigations as to the tides, he laid down contour lines of the bottom of the sea, at successive depths of 10 fathoms each. This discussion would lead to an important result if it were the means of inducing the authorities to direct the preparation of a contour chart of the sea, within the depth of 70 or 100 fathoms, all round the British Isles. It was pointed out that the maps of a series of tides, as actually observed, showed some remarkable phenomena in the North Sea, as well as in the Frith of Forth. In some parts of the latter, as on some parts of the coast of Holland, there were four tides in twenty-four hours. Some engineers thought that the occurrence of four successive high-waters was owing to local disturbances only; but continuous observations, taken night and day at a great number of stations on the Frith of Forth, and extended over three months in the year 1840, under the direction of a committee of the British Association, showed that these phenomena were not of local origin. At Stirling there were four high-waters, but the low-water was like that in other rivers. At Alloa, lower down the Forth, there were two low-waters in each tide, as well as two high-waters, or four of both every twenty-four hours; and these, or symptoms of them, were visible all the way down to the sea. It was argued that these anomalies arose from the two tides which entered the North Sea from its opposite or north and south entrances; one effect being due to the northern stream of flood, and the other to the southern wave passing through the Straits of Dover, which, when it arrived at the Forth, was twelve hours older than that from the north, and entered the Forth two hours sooner than the next following tide from Aberdeen. This reasoning led to the belief that the early tide was the irregular or Dover one, and that the later tide was the regular or Aberdeen tide. The diurnal inequality in the height of the tides was generally known, but the diurnal inequality of the time of that tide, though known in theory, had not been previously ascertained by observation. If a tide coming in from the south was of the same age as another coming in by the north of the North Sea, they would be both larger in the morning and both smaller in the evening; they would both be earlier in the morning and both later in the evening. But if they were of different dates—twelve hours apart—then one was a morning-tide and the other an evening-tide, and the one would be larger while the other was smaller, and each pair of tides would consist of a smaller and a larger and an earlier and a later together. This was exactly the fact as observed. The tides really traversed the shores just as if they were great waves of translation, the velocity of their transmission being regulated by the depth of the water.

Reference was then made to the manner in which the great wave from the Atlantic reached the shores of the United Kingdom; and the course the northern wave of the North Sea would take if it followed the law of a wave of translation, moving according to the depth of the sea and the velocity of the tidal-wave, was pointed out. The course of the southern wave was then traced; and it was remarked that the channel in the Straits of Dover was generally deeper in the middle and shallower at the sides, so that on the wave emerging from the Straits it would cling to the shallow shore, and form a convex line trending off towards the coast.

It was argued that the phenomena spoken of as occurring in the Frith of Forth might be easier accounted for by supposing that one high-water was produced by a tidal current along the shore, and the other coming later in from an offing current. Also, that the wave passing through the Straits of Dover would expend itself over the wide area between the coast of Holland and Lynn Deeps, and then come to a perfect level; and that, before the tidal-wave from Dover could reach the Frith of Forth, it must cross low-water—for while it was high-water at Dover and at the Frith of Forth, it was at the same time low-water in Lynn Deeps.

It was stated that the soundings north of Flamborough Head, and from the coast of Norfolk to the Texel, were doubtful, and that the Admiralty surveys had not been carried out to such an extent, or with so great minuteness, as to enable contour lines to be correctly drawn over the whole area of the North Sea in that latitude. Fishermen who were constantly trawling over the Dogger Bank had reported that there was a regular north and south stream running over the bank at the rate of from 2 to 3 miles an hour. If that were the case, it was unreasonable to suppose that any great deposit could take place, and that the bank could be other than a natural formation.

It was contended that there were but few facts upon which to base a discussion. In the northern part of the North Sea, there were only two or three traverse lines of soundings, so that the course which the tidal-wave pursued from the entrance to the Baltic to the coast of Scotland was very doubtful. Again, there were only two observations as to the rise and fall of the tides in the North Sea, and such observations were both difficult and costly. As the Straits of Dover were only 25 miles across, whereas the North Sea immediately opened out to a breadth of 100 miles, and the depth remained about the same, it was argued that the tidal-wave after passing through the Straits of Dover would be broken into a number of small waves and be annihilated. With respect to contouring the bottom of the sea on charts, it should be remembered that sailors wanted white paper, so as to be able to mark their positions off in pencil. Under these circumstances it was suggested whether, as the coast sheets of the Ordnance map were frequently blank, the contouring of the shores might not be undertaken by that department.

It was contended that it was the great tide coming from the southward into the Atlantic Ocean which fell upon the shores of the British Isles, and not that from the north-west. The course of the great ocean wave, or ocean stream, which was to fall into the North Sea, was then traced. It split off the west coast of Ireland, part going to the north and part to the south at Cape Clear. The southern tide thus entered the Irish, the Bristol, and the English Channels. In the English Channel it first entered a space of about 100 miles, between the Land's End and Ushant. It was then checked in its progress between Portland and Cape La Hogue, where the width of the channel was reduced to about 53 miles; and then between the South Foreland and Cape Grisnez the width was reduced to 20 miles. The Atlantic was thus pressed into the English Channel, and being hemmed in at the Straits of Dover the great rise of tide in that district naturally occurred. The same effect was produced in the Bristol Channel. With regard to the northerly tide, the width between the Orkneys and the coast of Norway being about 400 miles, and between Yarmouth and the Texel—the narrowest part—170 miles, it was inconceivable that the north tide stream could be overcome by such a comparatively small stream, only 20 miles in width, as could pass through the Straits of Dover. It was thought that was sufficient to answer the theory that the flood tide of the North Sea was from the southward, and passed through the English Channel. The late Admiral Beechey had divided the tide into establishments, and found that the tides between the Start Point and Lynn Deeps was one establishment—that was, that the flood-tide came round the Orkneys, passed along the east shores of England and Scotland, and was meet by the southern ebb off Lynn Deeps. The flood-tide then curved round to the southward of the Dogger Bank, crossed the Texel, passed on to Heligoland, then deflected into the Sleeve, stopped from entering the Kattegat at the Skaw, and finally turning round in the Sleeve towards Christiania, and thence round the Naze of Norway. The flood-tide in fact going to the north at that point, having made nearly a circle.

It could not be denied that the Dogger Bank, which might be called the bar of the North Sea, was of vast importance in the consideration of the question of the tides. As to its origin and the cause of its present position, it was urged that it had been formed in the same manner in which bars of rivers were usually formed; as the result of the conflict of the two opposite tides or streams, which had been described as meeting at Lynn Deeps. There was double the depth of water on the north side of the Dogger Bank that there was on the south. That was an additional reason why comparatively shoal water passing through the narrow Dover Straits over the southern part of the North Sea could not make its way as flood-tide to the Frith of Forth as had been suggested.

It was remarked that there were two tides in many places; for instance at Portsmouth and the places adjacent, the one tide came up the Solent between the Isle of Wight and Hampshire, and the other south of the island. It was suggested that the phenomena described as taking place in the Frith of Forth were more the result of the casual augmentation of the body of water by the sudden discharge of freshes from time to time, than from any fixed laws producing two tidal-waves. The same thing had been observed in the upper part of the tidal navigation of the Tyne. There appeared to be 11 feet of water over the bar at the Frith of Dornoch at low-water, which was about the average depth of the river; and it was asserted that extended tidal observations would show a decided slope in the surface of the water at the time of low-water, when there was a fair ordinary ebb. Many false tidal results were deduced from observations taken by the Coast Guard officers at improper places, and which did not give the true sea-flow. At Shields harbour, with easterly winds, the tide was frequently kept from ebbing to the ordinary low-water at sea, although there might at the same time be a good clean ebb further up the river; thus making the seaward reaches of the river appear to have little fall at low-water, whilst with a true ebb at sea a considerable fall would be found to exist.

It was mentioned that the double tides alluded to also extended along the Dorsetshire coast, and that they might all fairly be attributed to local rather than to any great oceanic causes. One great force which no doubt exercised a powerful influence in the North Sea had not been referred to—that was the current from the returning Gulf Stream, coming from a northerly towards a southerly direction, and therefore helping to keep back in some degree the tide which forced its way through the Straits of Dover.

The wave from the westward traversed the western seaboard of Ireland and Scotland in about eight hours, and the English Channel in the same period of time. The wave from the north-east of Scotland to the mouth of the Thames made low-water in juxtaposition with high-water on the other side. It was low-water off the coast of Yarmouth at the time it was high-water at the mouth of the Thames: in effect twenty hours elapsed before high-water reached the entire sea-board of Great Britain. At Fair Head and at Arklow—the north-east and south-east points of Ireland—there was scarcely any rise of tide. This seemed to show that the intersection of the reversed waves took place at these neutral points; for it was low-water in the offing N. and S. of Ireland when it was high-water in the narrow Irish sea, and *vice versa*, high-water in the offing when it was low-water in the Channel. The same thing occurred in the English Channel, for at Portland the rise of tide was only 7 feet, whereas at the Land's End and at Dover it was relatively 20 feet and 19 feet. Again, there was the same extraordinary falling off in the range of the tide on the Norfolk coast, for in Yarmouth roads the rise of tide was only 8 feet, whilst off Flamborough Head it was 16 feet, and at the mouth of the Thames it was 15 feet. High and low water at the entrance to the English Channel and off Flamborough Head would alternate nearly with the same periods of tide in the Straits of Dover; and Portland and Yarmouth were situated near the intersection of such reversed waves.

Attention was called to the article 'Tides' in the *Encyclopædia Metropolitana*, by Prof. Airy, in which it was stated that there was a third tide in the Forth, locally termed the "Leaky." Also to a paper "On the bed of the North Sea," by Mr. Robert Stevenson, published in the *Edinburgh Philosophical Journal* for 1820, in which the effect of shoals was discussed, and the conclusion arrived at that the shoals were increasing, and that there must be a general rising of the water level, upon the assumption that the same volume of water continued to flow into it. Those conclusions were at variance with the opinions generally entertained on the east coast, as ancient records and present appearances went to show that the water level was lower than formerly; or at all events that there was a considerable difference between the present and former range of tide, as compared with the level of the land. It was contended that the increased range of the tide on approaching the river Thames down the east coast was due to the indirect tide from the north overrunning the direct tide coming through the Straits of Dover.

In reply, the double tides in the Solent and at Southampton were explained, the one stream of flood entering the Solent from the westward, making its high-water; and the other stream of flood south of the Isle of Wight, meeting the former off Portsmouth. On the reflux of the latter it took the course of the Solent, and caused the second high-water at Yarmouth and other places westward as far as Poole. The Dogger Bank acted in a similar manner to the Danish coasts as the Isle of Wight to that of Hampshire, causing two high-waters and two low-waters from the Horn Point northwards. One tide traversed the coast of Scotland and England to Flamborough Head, then passed through the Outer Silver Pit, and thence made for Heligoland; whilst the other tide from the north passed east of the Dogger Bank to the same point. Reference was then made to a series of tidal observations from Heligoland to the Skaw, the results of which were communicated to the Admiralty in 1838, from which however deductions only had been made as to the establishments of different ports. These tides were now plotted in diagram, and it was apparent that they diminished in range as they went northward, the evening-tide being the predominant one at certain periods of the month, and showing two high and two low waters on different points of the coast. With regard to the tides in the Frith of Forth, it was thought a more simple theory could be developed than that which had been suggested. There were three great streams of flood which entered the Forth, one running down the coast, a second outside the Bell Rock, and the third stream, traversing the deep water outside, and having the greatest velocity, entered earlier than the other streams. That was the cause of the two high-waters, and their ebbing produced the two low-waters. It was considered that the reason of the morning-tide being the highest at one time and the evening-tide at another, and *vice versa*, was not so much due to the season of the year as to the declination of the moon. Assuming that the lower morning-tide entering the Forth must be the higher evening-tide at Heligoland, this on its reflux, being caught by the entering evening-flood, would be thrown into the Frith of Forth, and *vice versa*, causing the irregularity in the diurnal curve, on which there had been much discussion. In reference to the co-tidal lines shown on Dr. Whewell's chart, it was suggested that the contouring of the bottom of the sea should be a primary object, as unless that were done just conclusions could not be arrived at.

A series of observations had been made on the rise and fall of the water at the Three Crown Battery at the entrance of the harbour of Copenhagen, extending over a period of twelve years, from which a datum or daily level had been deduced. By condensing these observations into months during the years 1858 and 1859, the following was obtained: 1. That for eight months in the year the water varied from 1·885 feet + D.W. (daily water) to 1·623 feet — D.W. = a range of 3·508 feet. 2. That for three months in the year the water varied from 2·098 feet + D.W. to 1·885 feet — D.W. = a range of 3·983 feet. 3. That for the remaining month of the year the water varied from 3·147 feet + D.W. to 3·109 feet — D.W. = a range of 6·256 feet. 4. That during the last-named period, for some four or five days in the year, the water varied from 4·42 feet + D.W. to 4·196 feet — D.W. = a range of 8·616 feet. These effects were produced from the action of the wind in the North Sea and the Sound on the one hand, and in the Baltic on the other.

It was noticed that at Copenhagen, whilst the water was only brackish, and indeed almost fresh, when there was an outset from the Baltic due to the prevailing wind, yet the water from the chalk at a depth of 25 or 30 feet had been found to be quite salt. As to the Dogger Bank, it was remarked that the effects of the waves upon the detritus carried along the shore of the eastern coast of England had been carefully watched; when it was found that in calm weather with off-shore winds the sand accumulated along the littoral, and with on-shore gales it was washed away, and transported further south. As to the material of the *debris*, referring to the geological map of England, attention was called to the successive deposits of the old red sandstone, the mountain limestone, the millstone grit, and afterwards the coal measures, at this time the whole of the eastern coast of England being under water. Then succeeded the new red sandstone, the oolite, and the chalk. In England all these formations came from the north, and the detritus of the present day was brought from the same direction, forming the shoals on the coast of Norfolk and the Dogger Bank. It was thought that there must be currents over that bank, though not so strong as in the deeper water, as it was covered with water, and the flood made in one direction and the ebb in another. In conclusion the hope was expressed that engineers locally connected with harbour works, and those also engaged on railways in immediate connection with harbours, would take the levels from the Ordnance bench-mark to the established high-water of the place, when the important question could be solved, whether the sea was level at low-water or at half-tide.

In closing the discussion it was remarked that it was immaterial to engineers how the Dogger Bank was formed, or whether it was rising or subsiding, provided neither effect was likely to take place for many generations. But there was no question that as regarded engineering in general the North Sea possessed features of great interest, and its phenomena were worthy of attentive consideration. With respect to the statement as to there being a diurnal variation in the tide at Copenhagen to the extent of 7 or 8 feet, it was thought that it should be received with hesitation, as the whole effect in narrow seas arose from the waves of the ocean, and was not dependent on lunar influences, and could only occur at the time of high winds; but there might be such a variation at some seasons. It was urged that there was no surplus flow of water to any extent from the Baltic into the North Sea; and that all the currents from Elsinore were owing to the prevaling winds. Prof. Airy had shown that the tides upon the east coast of England were owing entirely to the north wave coming round the Pentland Frith; whereas the tides on the coast of Holland were due to the waves travelling up the English Channel. The tides on the east coast were remarkably uniform, excepting when influenced by circumstances, as at Yarmouth. The extraordinary practical results of the wind-tides were then commented upon; and it was remarked, that whilst in the Thames it was only necessary that the banks should be 4 feet above high-water, yet in the Schelde and the Elbe, and all along the coast of Jutland, 11 and 13 feet had been found insufficient. It was thought that any current over the Dogger Bank must be a light one, and quite incapable of conveying sand from the shore to it. It was evident that there was a great mechanical action going on in the North Sea; as there was a considerable current running to the east from the Dover coast to Christiania and the Naze. That current was constant, and its intensity varied with the force of the wind, which was generally W.S.W.

COLOUR ROUND STATUES.

By John Bell.

While however, for the reasons already given,* I am opposed to placing various colours on a statue, especially a marble one, I have no idea of underrating the value of colour in connection with statues. On the contrary, I am sure that this subject of the association of various treatments of colour with statues has not received nearly the study and attention it deserves. My difference with the statue-polychromists is not that I do not desire colour and statues together: in that we both agree that it should be so. Our difference only exists in the mode in which this should be done: they desiring to place colour on the statue itself, so as to make it harmonise with the surrounding objects; while I submit that this harmony is to be effected far better by other means—namely, by arranging such colours around the statue as require the natural pure, creamy, semi-transparent, local tint of the marble to complete the composition of colour. And the same, *mutatis mutandis*, may be said of statues in bronze, which is indeed a quality of colour frequent in the finest paintings, as in those of Titian and Giorgione, and in the landscapes of Gaspar Poussin, and our own Wilson, Crome, and Turner. It is thus I conceive that the picture should be made up, with the statue as the eye of the composition, and that the surface of the statue itself should not be deteriorated by any colour treatment; which, if once commenced, you know not where to stop, and which, if treated up to the full colour of flesh, only makes the statue look like a wax image.

I do not attempt to enter now on the treatment of colour with statues in edifices of which they form an illustrative and integral part. That were a very wide field indeed, including the whole subject of architecture, painting, sculpture, and decoration, and their relation—enough indeed for several addresses. On the present occasion I limit myself to that part of the subject alone which attaches to the treatment of colour with statues in art exhibitions, under such arrangements as are practicable on such occasions. A few weeks ago I touched briefly on this subject in some notes I read at the Department of Art, Kensington, entitled "the Four Sisters;" but perhaps you will permit me now for a few minutes to go into more detail. The more so, inasmuch as I submit that the inadequate treatment of colour in connection with sculpture has hitherto formed an important item in the shortcomings of our current exhibitions of this art.

The situations in which, round a statue, colour presents itself are—below it, behind it, and above it; on the floor, the background, and the ceiling. Of these, of course the background is the most important to the statue, as it is that against which it is seen, and which contrasts immediately with its outline. Now it has been the prevailing custom, at least till quite of late years, to make this contrast a very strong one, and for this purpose a very strong dark red has been the favourite colour, as at the Royal Academy. I conceive this to be an error, and, as far as I have been able to influence decisions on the subject, I have done my best to introduce a change. On being called on, at the time of the great Exhibition of 1851 in Hyde-park, to arrange the British Sculpture there, I made it a stipulation that I should be allowed to depart from the violent red used and proposed up to that time as a background for statues, and to select a modified tint. Again, in 1855, being employed with Mr. Redgrave, by the Board of Trade, to arrange the British Sculpture in the International Exhibition in Paris, I used the same colour, which however on that occasion was seen under every disadvantage, from the darkness of the room allotted to that purpose. Since this, a similar tint has been adopted in the exhibition of British Sculpture at South Kensington. Also it has been partially used in the Crystal Palace at Sydenham, as a background for some of the ancient statues, and I believe that portion is best liked.

Thus it may be said, I think, that this treatment of tint has been to some degree endorsed by experience. This colour is not in a violent key, but a mild one, being a middle tint—a warm grey, not too dark or sombre. This, while it affords a sufficient relief for the outlines of the figures placed before it—more however from its atmospheric character and quality of retreating from the eye, than from its direct contrast—softens the outlines agreeably, and makes the forms before it look round and fleshy. If you notice the effect of flesh in nature, you will find the outlines never harshly projecting from the background, and in fine paintings accordingly you perceive this natural softness imitated. If we desire therefore by a background to gain the same agreeable appearance in statues, why should we not use similar means—viz. by a softening of the outline? If the background is such that the edges of the statue melt into it, then the statue looks round, and like nature. But if, on the other hand, the background asserts itself too much, and tumbles forward, as a strong red is apt to do, instead of retreating, like grey, and is moreover harsh and violent in its contrasts, then the outlines of the statue all round are thrown out upon you, and the figure looks flat, harsh, and unnatural. You know how inferior is the appearance of a plaster statue to that of one in marble, greatly from the opacity and therefore harsh edges of the one, and the semi-transparency and comparatively soft edges, like those of flesh, of the other. As a consequence, by a harsh treatment of background you may thus make a marble statue look like a plaster one. While on the other hand, by a suitable tender background of sufficient contrast, and of a retreating atmospheric character, you may make a plaster statue look almost like a marble one. For this purpose delicate mixed tints are more appropriate than any more positive. However, pray do not conceive that I consider this individual warm grey the only colour suitable for the background of statues. By no means is this the case, and I only put it forward as one example of the class of colours, and not the sole colour, suitable for this purpose.

The material however in which these colours are presented is also important. Texture is important as well as tint. In these cases no material perhaps is more favourable for the background than drapery of some unglazed material, arranged not rigidly, but in easy folds, whereby it affords a more natural adjunct to the statue before it; its lines being adjusted so as to compose with the lines and masses of the statue, thereby advantaging its effect. Let us suppose the drapery woollen, of some simple rich texture, and graceful fall, and of some tender atmospheric tint, and let it be suspended along a wall space to be occupied in front by a few statues. Let the drapery hang comparatively plain immediately behind each statue, but in the intervals between be gathered somewhat together, so as to form columnar perpendicular folds. Thus is a semi-architectural effect attained without rigidity, in which plain panels are simulated behind the statues, and columns between them. The result of this is pleasantly regular and yet gracefully varied, and is capable of the most easy adaptation to the various breadths and scales of statues or groups placed before it, and also to any changes of their places which may occur in the course of arrangement. Taking this as an example of the principle of arranging drapery as a background to statues, it may be recognised as capable of practice in so many ways, in simulation of forms of architecture, as to suit it to the exhibition of any kinds or classes of sculpture. No doubt when a statue is composed especially for some express architectural space in a building, it ought to look best there, associated with the actual architecture for which it is designed; but in exhibitions where the placing of statues is comparatively unrehearsed, statues will probably harmonise better with drapery accompaniments than with more rigid and precise forms, in relation to which they have not been originally composed, and in which congruity is difficult if not impossible.

This also is a semi-pictorial treatment of sculpture, inasmuch as thereby a varying artificial atmospheric background is formed and composed behind each statue, as a simulation of nature's sky and clouds behind a portrait or figure in a picture, whereby the principal object is enhanced. On several occasions I have suggested this mode of enhancing statues by ample drapery backgrounds, and on more than one only considerations of expense have prevented its being adopted. It will be recognised that a mere flat tint, distempered or painted on the walls, is not calculated to give much idea of the effect of the same tint presented with the variety and grace of drapery, and therefore it were prejudicial to judge of the ultimate effect of drapery except by drapery itself. In the Louvre, behind the famous fragment of the Venus of Melos, drapery has been hung with excellent effect, and seats are placed at the best points to view it from—a mode which, in a gallery of exhibition, has many advantages. But the background is not the sole consideration. Supposing in a statue-gallery a warm grey has been adopted for the background, and the creamy-white statue stands before it—we have then to complete, by the choice of tints for the other parts, the composition of colour. With this starting point of warm grey for the background, I believe that the pedestal of the statue might well be covered with cotton velvet of a deep bronze green. The floor on which it rests might then be stained deep red and black, of a mosaic character, as seen in encaustic tiles. The ceilings might then receive some light delicate retreating atmospheric colour, with a little yellow introduced, which were best done by light gilding. This is one key of tint for the arrangement of light-coloured statues, which will rarely, I believe, disappoint the eye. Perhaps it is sufficient as an illustration of the principle I advocate. In cases where statues are darkened and embrowned by time, a different key altogether may be required. This however is the reason which I have received for the intense, and almost furnace-like colour placed behind some of the darker works in the British Museum.

---

* See *ante* page 168.

The whole question however of the effects of statues with colour presupposes a good light—namely, for most statues, at an angle of 45 degrees or thereabouts—falling on them from above. Recumbent statues are more favoured by a lower light, slanting down so as to show the features. Coloured lights, as in the Napoleon tomb in the Hôtel des Invalides, in the Princess Charlotte's tomb in the Chapel at Windsor, or in the Ariadne room at Frankfort, may not appear consistent with the dignity of art. In the case however of their being admitted as an aid to effect, as was probably the case in the Greek temples, all the other adjustments of colour might have to be reconsidered. In these remarks I only contemplate uncoloured light.

As regards bronze statues, a positive key cannot so well be given, as their tints are various, extending from dark Florentine bronze to the light golden browns of Paris. However, as a general suggestion, it may be remarked that a golden green is usually an harmonious background for a bronze statue. A polished black marble pedestal also is effective in taking the dark out of the bronze which stands on it, lighting up its shadows by contrast. In the absence of black marble, a covering of black velvet affords an agreeable substitute. In the immediate neighbourhood, vigorous warm colours may come in agreeably, as a Turkey carpet on the floor, and hangings around of rich velvet looped up with gold cord.

As a general rule, perhaps it may be said that tender colours in the background harmonise best with marble statues, and full colours with bronze, as we see the dark races the most attached to brilliant and powerful tints. With marble statues, delicate greens, azures, and purple greys, citrons, lilacs, and chocolates, supply charming backgrounds, the effect of the composition of colour being of course supplied by the other adjuncts. It may however be held generally that there should always be some strong colour somewhere. Of course these modifications of mixed tints are in art almost inexhaustible, as they are in nature. Yet, in connection with this subject of the due exhibition of sculpture, they require special means and scope for their presentation.

As I observed just now, I have on this occasion only had the opportunity of considering at all closely the subject of colour and statues in exhibitions. The same general considerations however hold when they are associated more intimately and substantially with architecture. Thus I would hope that, although restricted by my limits from going into the whole subject, the portion now taken to some degree illustrates my whole view—namely, that while the harmony of colour of statues with their *entourage* is highly important, that this does not necessarily entail the desecration of the surface of the statue itself, but that, on the other hand, this is more justly to be done by so selecting and adjusting the surrounding colours that they may require the natural tint of the marble itself to complete the picture.

The arrangement together of Paintings and Sculpture.

I am now nearly at an end, and have but few more words to add, which however will take us a little beyond the consideration of colour as merely subordinate and subsidiary to sculpture. I now allude to such cases wherein colour is presented by the sister art of painting, when exhibited together with sculpture in one and the same gallery. First, however, we will give a preliminary thought to that mode of the presentation of painting which still may be considered subsidiary, only however from the method and material in which it is worked—I mean tapestry. We well know that Raffaelle did not consider his master-mind and hand debased by designing for tapestry. The noble cartoons in Hampton Court are a sufficient evidence of this, having been executed by himself and his assistants expressly for this purpose. It is not however because the colours are produced in tapestry by the needle or loom instead of the brush that I speak of it as subordinate, but only in accordance with general custom. Pictures in fine needlework as hangings have usually been considered of the nature of furniture as well as art. Their textile rich surface expressly fits them for their subsidiary purposes. We may well suppose, for instance, that a beautiful classic group in Parian marble of Cupid and Psyche, would appear admirably on a pedestal of polished sienna and other marbles, standing in a room which should be surrounded with rich tapestries portraying their story, as told by Apuleius and other classic authors. Actually in practice indeed, tapestry, with its varied hues and texture, and subjects of interest, will often unite admirably with sculpture, as some of those present may have had the opportunity of observing.

We will now however pass on to the harmony of works of the two arts, painting and sculpture, when they meet on a level of direct equality, as in galleries for their reception. This is a point not for the sculptor alone to consider, but also for the painter; also for the general art-lover; also for the public—for opinions are various on this point. My own is that they may be made to harmonise perfectly in combined exhibitions, which thereby may be made the more attractive. Still, however, I conceive that this would require special arrangements, so that, on the one hand, the white tint and brilliancy of the marbles may not injure the effect of the pictures by too close a juxtaposition; and, on the other, that these may not injure the effect of the statues by the cross-cutting lines of the gold frames which surround them. Therefore, as a general rule, this might point to the conclusion that in a picture-gallery where sculptures are introduced, the latter should be at intervals, where special arrangements should be made. In the centre of saloons also, such statues and groups as look well in a downright line might well have situations; also at the meeting of cross-ways; also busts, or even statues on each side of doorways, but in these cases it would appear that they should have suitable backgrounds afforded by draperies or other materials.

Of the direct association, however, on a dignified scale, of works of painting and sculpture of a high class, but few examples exist in galleries of exhibition. Those which most readily occur are afforded by the celebrated Uffizi gallery at Florence. This was adapted by Vasari, in the early part of the seventeenth century, to the reception of works of art. It consists of two long corridors and about thirty rooms, in which works of painting, sculpture, and decoration are variously arranged. The Niobe room contains that well-known series of Greek statues. It also contains some historic pictures by Rubens, some portraits by Lely, and some hunting subjects by Snyders. The most celebrated apartment however in the Uffizi gallery is the Tribune, which also affords the best example of the exhibition together of works of the two arts; the works therein exhibited are of the highest excellence, reputation, and value. The works of sculpture contained in this room are five in number—the celebrated Venus de Medicis, the Apollino, the Dancing Faun, and the group of the Wrestlers, Boxers, or Pancratiasts, as they are variously called; also the Knife-grinder or Slave whetting his knife. The pictures are almost of equal celebrity, and are from forty to fifty in number. Among them is one picture by Michael Angelo, and several by Raffaelle; as the Madonna with the goldfinch, St. John preaching in the Desert, and the portraits of Pope Julius, of the Fornarina, and of a Florentine lady. Titian also has here his celebrated Venus, also another Venus, and a portrait of an archbishop. Paul Veronese has a Holy Family with St. John and St. Catherine. Also, there are examples within these walls of the works of other celebrated painters, as Annibal Caracci, Spagnoletti, Guercino, Daniel di Volterra, Correggio, Andrea del Sarto, and Vandyke, as well as the grand Isaiah and Job, by Fra Bartolomeo: so that this room presents an associated exhibition of works in both the arts not to be surpassed for beauty and excellence. Although I acknowledge I have met with some who have taken exception to the arrangement of this room, yet by most it is highly admired. I think it may be said generally to be by far the most interesting room of art in the world. One more often hears it spoken of, and that with high admiration, than any other room of art, and in this the works of painting and sculpture are associated.

There are on the Continent some other examples of galleries of exhibition (for to that section I restrict myself), in which works of painting and sculpture are associated more or less happily. Occasionally also, on a very small scale, we have seen this done in London, as at the British Institution. Also, in the International Exhibition in Paris, in 1855, this was done with good effect. In some degree indeed we set the example on that occasion, as mentioned at page 81 of our bound reports of that Exhibition, in which it is stated—"After many applications, the Imperial Commission at length assented to statues being placed down the centre of our picture-gallery: when arranged, the general effect was so satisfactory that it led to a like treatment being adopted for foreign statues in the corresponding galleries of the building." This theory however of combination is, I conceive, capable of much more development than it has as yet attained; and that in practice, with due attention and scope, the exhibition together of the works of these two sister muses of the fine arts may be made eminently attractive and complete in effect, perhaps more so than by any other method. As such I would submit it as a worthy subject for discussion.

◆

DEFLECTION OF SUSPENSION BRIDGES.

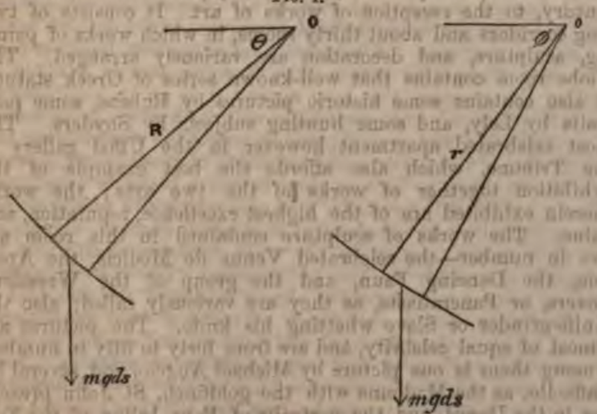
By Homersham Cox, M.A.

The following investigation of the deflection of a suspension bridge due to a deflecting weight placed at an assigned point of the bridge, is applicable not only to the case of a chain of uniform thickness, but also to the more common case in practice of a chain of varying thickness. It is believed that no investigation of this subject has been published.

The method here adopted is necessarily approximative, as the formulæ of catenaries are so complex, that it would be impossible to treat the subject with rigorous exactness. But the closeness of the following approximation to the truth is probably quite sufficient for practical purposes. It will be here supposed that the points of suspension are fixed and of equal altitude; that the platform is perfectly flexible, and subject to no horizontal tension; that the deflecting weight produces a variation of the vertical distance of each point of the chain below the points of suspension which is small compared with that distance; and that (as in practice) that distance is small compared with the horizontal span of the bridge.

Let the small arcs in Fig. 1 represent a small element of the length of the chain before and after the deflection respectively; R, r the radii of curvature of those arcs; O, o their centres of curvature; ds their length; $mgds$ their weight; θ, ϕ the inclinations of the radii of curvature to the horizon; T, t the tangential tensions acting on the element before and after deflection respectively; C, c the horizontal tensions before and after deflection respectively.

Fig. 1.



Then, since the horizontal tension at every part of a catenary is the same,

$$\mathrm{T}\sin\theta = \mathrm{C}\,;\quad t\sin\phi = c \quad \ldots \quad \ldots \quad (1)$$

The angles θ, ϕ differ little from each other. Also $\sin\theta$, $\sin\phi$ do not greatly differ from unity, since the inclination of the chain to the horizontal is everywhere small. Consequently, $\frac{\sin\theta}{\sin\phi}$ differs from unity by a quantity which is small compared with unity.

Therefore approximately, $\frac{\mathrm{T}}{t} = \frac{\mathrm{C}}{c} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$

Resolving along the normal the forces acting on the element, we have

$$\mathrm{T}d\theta = mgds\sin\theta;\quad td\phi = mgds\sin\phi.$$

And as before, putting the ratio of $\sin\theta$ to $\sin\phi$ equal to unity,

$$\frac{\mathrm{T}}{t} = \frac{d\phi}{d\theta} \quad \ldots, \quad \ldots \quad \ldots \quad (3)$$

Therefore from (2)

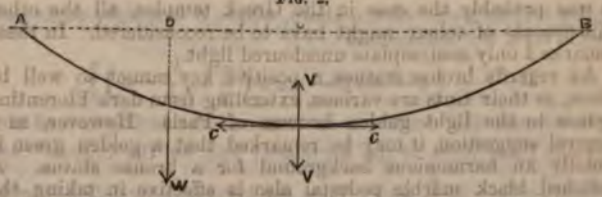
$$\frac{d\phi}{d\theta} = \frac{\mathrm{C}}{c}, \text{ and } d(\phi - \theta) = \frac{\mathrm{C}-c}{c}\,d\theta \quad \ldots \quad \ldots \quad (4)$$

Integrating equation (4), $\phi - \theta = \frac{\mathrm{C}-c}{c}\theta + \text{a constant} \quad \ldots \quad (5)$

It is to be observed that m is not here assumed to be constant; so that the result is not confined to the common catenary. It may be added that the relation between θ and ϕ may be found by an integrable equation, without assuming $\sin\theta = \sin\phi$.

In order to determine this constant we may proceed as follows: Let the curve, Fig. 2, represent the deflected catenary; W the deflecting weight acting at an assigned horizontal distance AD$=a$ from the point of suspension A. Let AC$=$CB$=h$. Let the depth below AB of the middle point of the chain be k. The tension at that point is not horizontal, but has a vertical component; let this be V. The horizontal component we have already designated c. Let the half chain suspended from A have its centre of gravity at a horizontal distance b from A, and let S be the weight of the half chain. Then taking moments about A for the equilibrium of the half chain, we have

Fig. 2.



$$\mathrm{W}\,.\,a + \mathrm{S}\,.\,b = c\,.\,k + \mathrm{V}h.$$

As the displacement of every part of the chain is small, the difference between the quantity k and the value of that quantity before deflection is small compared with k. The same consideration applies to b. We may therefore define k to be the depth below AB of the lowest point of the *undeflected* chain; and b to be the horizontal distance of the centre of gravity of either half of the *undeflected* chain from its point of suspension.

Taking moments about B for the equilibrium of the half chain suspended from B we have

$$\mathrm{S}\,.\,b = c\,.\,k - \mathrm{V}h.$$

From the last two equations we get

$$\mathrm{W}\,.\,a = 2\mathrm{V}\,.\,h;\quad \mathrm{W}\,.\,a + 2\mathrm{S}\,.\,b = 2c\,.\,k.$$

From the last equation, putting W$=0$,

$$\mathrm{S}\,.\,b = \mathrm{C}\,.\,k.\quad \text{Therefore } \mathrm{V}\,.\,h = (c-\mathrm{C})k.$$

Whence

$$\frac{\mathrm{V}\,.\,h}{c\,.\,k} = \frac{c-\mathrm{C}}{c} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Let a be the value of ϕ for that part of the chain which is horizontal before deflection. Since for that part of the chain $c = t\sin a$ and $\mathrm{V} = t\cos a$,

$$\frac{\mathrm{V}}{c} = \text{cotan}\,a = \tan\left(\frac{\pi}{2} - a\right) = \frac{\pi}{2} - a \text{ nearly,}$$

since a is nearly a right angle. Hence

$$\frac{\pi}{2} - a = \frac{V}{c} = \frac{k}{h} \cdot \frac{c-C}{c} \quad \ldots \quad \ldots (7)$$

Returning now to equation (5) we have when θ is a right angle and $\phi = a$,

$$a - \frac{\pi}{2} = -\frac{c-C}{c} \cdot \frac{\pi}{2} + \text{the constant.}$$

Therefore from (7) the constant $= \frac{c-C}{c}\left(\frac{\pi}{2} - \frac{k}{h}\right)$, and equation (5) becomes

$$\phi - \theta = \frac{c-C}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right) \quad \ldots \quad \ldots (8)$$

Let the curve be referred to rectangular co-ordinates, the origin of co-ordinates being the lowest point of the undeflected chain, and the axis of x horizontal. Let x, y be the co-ordinates of the element before, x', y' its co-ordinates after deflection.

$$\frac{dx}{ds} = \sin\theta, \quad \frac{dy}{ds} = \cos\theta, \quad \frac{dy'}{ds} = \cos\phi,$$

$\cos\phi = \cos[(\phi-\theta)+\theta] = \cos\theta - (\phi-\theta)\sin\theta$ nearly, since $\phi - \theta$ is small.

Hence from (8).

$$\frac{dy'}{ds} - \frac{dy}{ds} = -\frac{c-C}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right)\sin\theta \quad \ldots (9)$$

Now ds is equal to $\mathrm{R}d\theta$, and since the radius of curvature is everywhere large and varies little, we may integrate the preceding equation, assuming R to be constant.

$$d(y'-y) = -\mathrm{R}d\theta\,\frac{c-C}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right)\sin\theta$$

$$y' - y = \mathrm{R}\frac{c-C}{c}\left\{\left(\frac{\pi}{2} - \frac{k}{h}\right)\cos\theta - \theta\cos\theta + \sin\theta\right\} + \text{a constant.}$$

Let the value of θ at the summit of the chain be β, then since at that point $y' - y$ is zero, we have from the last equation

$$y' - y = \mathrm{R}\frac{c-C}{c}\left\{\left(\frac{\pi}{2} - \frac{k}{h}\right)(\cos\theta - \cos\beta) - \theta\cos\theta + \beta\cos\beta + \sin\theta - \sin\beta\right\}$$

At the middle point of the chain, where θ is a right angle and $\cos\theta$ is zero, the deflection is

$$\mathrm{R}\,\frac{c-C}{c}\left\{1 - \sin\beta - \cos\beta\left(\frac{\pi}{2} - \frac{k}{h} - \beta\right)\right\}$$

or, to express the deflection in terms of the inclination of the curve at its summit to the horizontal line, let the angle of that inclination be $\gamma = \frac{\pi}{2} - \beta$. Then the last-mentioned deflection is

$$\mathrm{R}\frac{c-C}{c}\left\{1 - \cos\gamma - \sin\gamma\left(\gamma - \frac{k}{h}\right)\right\}$$

When R is taken as constant, $\mathrm{R}(1-\cos\gamma) = k$ and $\mathrm{R}\sin\gamma = h$. Hence we may readily show that $\sin\gamma = \frac{2hk}{h^2+k^2}$. Put $\sin\gamma = \gamma$ in this expression, since γ is very small. Therefore the above expression for the deflection at the centre of the chain becomes

$$\frac{c-C}{c}\left\{k - h\left(\frac{2hk}{h^2+k^2} - \frac{k}{h}\right)\right\} = \frac{c-C}{c} \cdot \frac{2k^3}{h^2+k^2}$$

an expression from which the deflection at the centre is easily computed. The deflection at any other point may also be found from the general expression for the deflection by substituting for $\cos\theta$, $\sin\theta$, and θ their equivalents in terms of the rectangular co-ordinates of the point of which the deflection is required.

The mode of computing c and C is given by the equation (6). It may be observed that in practice these tensions may be computed with sufficient accuracy by assuming the centre of gravity of each half chain to act at a horizontal distance from the summit equal to the quarter-span. This is the position which the centre of gravity would have if each half of the chain were regarded as a straight uniform bar, and the deviation of that assumption from the truth produces no considerable error. We have then for the undeflected chain the following simple formula for the horizontal tension:—

$$\frac{\text{Horizontal tension}}{\text{Weight of half chain}} = \frac{\text{quarter-span}}{\text{total rise of chain.}}$$

In the common catenary this result may be obtained analytically, for if the origin be at a distance c below the lowest point of the catenary, and

$$y = \frac{c}{2}\left(e^{\frac{x}{c}} + e^{-\frac{x}{c}}\right)$$

Since $\frac{x}{c}$ is very small, we have by expansion

$$y = c + \frac{x^2}{2c} \text{ nearly, or } c\,.\,(y-c) = x\,.\,\frac{x}{2}$$

which is the equation which would be obtained by equating the moments about the summit of the forces acting on the half chain, and assuming the centre of gravity to have the position last mentioned. In ordinary suspension bridges, in which the chain is somewhat more massive at the highest points than at the centre, the same equation is approximately correct, for the variation of the massiveness of the chain is not great, and it brings the centre of gravity of the half chain rather nearer to the point of suspension than is the case in the common catenary, in which the centre of gravity is at a distance from that point somewhat greater than the quarter-span. From the last equation it appears that the catenary in practical cases is very nearly a parabola.

ON ARCHITECTURAL COMPETITIONS.

(*Continued from page* 168.)

It is a thankless task to detail grievances or evils for which there is believed to be no remedy; and had we considered the disadvantges of the competition system as at present prevalent among us to be such as admitted of no modification, or so intimately connected with the whole system that there could be no reasonable hope of their removal, it is probable that we should not have drawn attention to them. It is because these things are not indispensably necessary that we have thought it right to make them matter of inquiry; and it has been throughout proposed to conclude these observations with some suggestions for the improvement of our practice in this respect.

Clearly the public are not to be expected to take the initiative in such a reform, although no reform can be of use which is not of a character at once to influence and to be influenced by the public. On the general body of architects lies the onus of initiating improvements the necessity for which they alone can fully appreciate. To public opinion, convinced by their representations, or if necessary overpowered by the attitude they take up, remains the task of giving weight and effect to the measures proposed.

We have then these questions to solve—first, How is unanimity of feeling and action in relation to competition to be attained among the members of the architectural profession?—secondly, How best are they to influence public opinion?

There can be no denying the truth of the statement, that were *all* the architects of Great Britain to concur in pursuing one course with regard to any part of their practice, the public would be obliged to perforce submit to their determination. For example, were it unanimously resolved by them, and the resolution uniformly carried out, that no one should enter into a competition where the execution of the work was not unconditionally promised to the successful competitor, it is easy to see that this would become an universal rule of all competitions, simply because no drawings would be sent to persons inviting them without such a condition. A moment's reflection will however convince any thoughtful person that, however simple a mode of settling the question this may appear, it is an impossibility to put it in practice. Such unanimity on even a single point would be unattainable, and even if possible, unless the step received the concurrence of the public, could not fail to be speedily overthrown.

What we have to look to then is, not a perfectly unanimous action such as shall prescribe a course which the public cannot choose but follow from necessity; it is rather such an agreement as, while making action in the main uniform, shall exert its influence powerfully on the public mind. For this agreement nothing more would be needed than a raising of the standard of the profession, and a cultivation of more of that professional feeling which among the legal and medical bodies does so much to promote uniformity and respectability of practice. Both these things are in progress—they are of slow growth however; and although perhaps it may be true that till they have come to maturity no entire and radical rectification of our system is to be hoped for, a quicker though less complete method of action seems to offer itself in combinations of members of the same profession into societies, or in other forms of collective deliberation and action. The most high-minded and the most enlightened often succeed in exerting an influence over public bodies such as causes the action of those bodies—nay, even their deliberations—to rise above the standard natural to the majority of those constituting the assembly; while, in a less degree, the public press enjoys the privilege of exercising something of the same influence over a large circle of readers.

To the influence of existing societies then, and especially to the action upon those bodies of the most enlightened of their members,—to the formation of new societies or a new society for the express purpose of regulating competition and other matters of practice,—and to the influence of the public press, we look for the first steps in the way of improvement.

Here it may not be out of place to observe, that the existing societies have as yet done but very little indeed to clear up the question, and that there seems ample scope for the lately proposed scheme of an "architectural alliance" among all existing architectural bodies, having among its leading objects the regulation of professional matters such as competitions.

If any one society, or the associated societies, or any other active nucleus, would set itself to work to ascertain what the views of the profession are upon various points, so as to be able to publish a concise statement of them where they agree, and to promote discussion upon them where they differ, the first step would have been taken. Could a decision be arrived at upon even only one or two points, and printed, and the adherence of a large number of architects obtained,—such a document, even though not including a pledge in so many words to compete under no other terms, would yet carry immense weight with the profession, and if means were taken to obtain a wide circulation for it among public bodies and in all the leading journals, there can be little doubt that it would be no less powerful in its influence upon the general public. Supposing, for instance, such a paper as the following to be extensively and influentially signed: "We the undersigned, being engaged in the practice of architecture, consider that it is indispensable to the equitable and satisfactory conduct of architectural competitions that the following regulations should be observed by those engaged in them and those having the direction of them"—the regulations subjoined to it would no doubt be constantly adopted, and for the most part adhered to. It would be desirable that these regulations should be few in number, should have reference to essential points only, and should be such as would command general assent—disputed points being left out of them altogether. Possibly the following would comprise all the points upon which a nearly unanimous agreement could be secured, and perhaps even fewer topics ought in the first instance to be introduced:—

1. That the successful competitor should be the architect of the building, upon the usual terms.

2. That the drawings be signed with their authors' names in any case where a professional judge is not employed.

3. That in all cases professional assistance be obtained to ascertain that the plans submitted can be executed for about the amounts estimated; and ordinarily such assistance ought to be sought in the entire decision.

4. That any infringement whatever of the rules shall absolutely exclude a set of plans from the prize.

5. That all plans submitted shall be publicly exhibited after the award is made; and, if they have been sent in with mottoes, that their authors shall have an opportunity of affixing their names.

Supposing even that no opportunity for concerted action of this description occurred, or that such a paper as the one we have suggested were found impracticable, it is at any rate certain that such views, if advocated at the meetings of the various architectural societies, and especially if promulgated by the Royal Institute of British Architects, could not remain altogether without influence, and it is above all things desirable that the subject should be extensively and intelligently discussed.

How far the management of competitions is to be improved depends, we repeat, upon the conduct of the profession and the influence which the profession can exert upon the public; and although litigation is always a troublesome process for those actually engaged in it, yet it cannot be forgotten that sometimes a single decision of the courts exercises a great influence upon the public—very many things are generally known only through the fact that they have formed the subjects of conspicuous trials, and we cannot help believing that an architect—or all the unsuccessful architects—in some competition where a notorious breach of the preliminary conditions may have occurred, would not only be justified in proceeding legally against the managers of the undertaking, but would confer an inestimable public service upon their fellow-architects by their doing so; nor is it too much to say that instances have occurred, and will occur again, where it would be right for a public fund to be raised in order to establish the right of competitors to a decision in accordance with the conditions under which they were first invited.

Two former attempts to introduce this subject to professional notice deserve a record here. The first of these was a discussion of it some years ago by the Architectural Association, which resulted in the proposal to establish a code of laws or regulations, which regulations were very carefully framed and were submitted to the Royal Institute. Though no very tangible results have followed, yet this effort has no doubt had the effect of spreading sound views on the point, and has remained unforgotten if perhaps inoperative. Subsequently the subject of competitions came under the notice of the senior architectural society in London (the Institute), being the subject of a very able and comprehensive paper read before the members by Mr. George Morgan; and though no action has been taken, no doubt sound views have been further extensively diffused by this paper. Were this plan repeated—were there more opportunities of discussion afforded, there can be no doubt of a good result.

While these papers have been in course of publication, a pamphlet on the same subject from the pen of a well-known French writer on architecture has appeared, and adds one more published opinion of value. M. César Daly, the editor of the *Rêvue Génèrale*, has published a pamphlet, provoked by the late competition for the Opera-house in Paris, in which he reviews the subject as it affects public monuments. As this opens up rather new ground, and at any rate introduces several considerations of importance, we propose in another article to give an account of M. Daly's work; and also to refer to some of our own more celebrated competitions for public works, and to what could be effected by a thoroughly well regulated system of public competition, both in public and other works.

◆

IRON GIRDER BRIDGE FOR THE BOSTON AND WORCESTER RAILROAD, U.S.*

By E. S. Philbrick.

This structure crosses the Watertown road, Brighton, U.S., and was built by Adams and Co., of Boston. Though differing in many of its details from any bridge of the kind hitherto constructed, the same ratio was used in the proportioning of the metal to the strains incurred as in other similar English and American bridges—viz. a maximum tensile strain of 4½ tons and a compressive strain of 4 tons per square inch of section, incurred by a live load of 1 ton per lineal foot of track. It consists substantially of three girders of the **I** form, supporting on their tops a floor and double-track railway, the girders being braced against each other in a thorough and rather peculiar manner.

The span is 86 ft. 10 in. between bearings, approaching the limit where a tubular form would be preferable to a series of separate girders, and therefore requiring a degree of strength unusual in the **I** form of girder. The middle girder, having sometimes to support two trains at once, should they chance to meet on the bridge, is made proportionally strong and rigid, as fully proved by the test load described below.

The great obliquity of the bridge (there being an angle of only 21° 30′ between the tracks and the abutments), while largely increasing the length and cost of both masonry and superstructure, is an advantage when compared with a right-angled bridge of a similar span, because each girder is here supported laterally by the abutment itself throughout one-third of its length.

The horizontal members at the top and bottom of the girders, devoted to resisting the compressive and tensile forces respectively, are all 2 feet in width, varying in thickness to conform to the strains to which they are subject. Their joints are spliced with plates of the same width, on both sides. They are attached to the vertical sheets or web by a 4-inch by 4-inch angle-iron on each side of the latter, passing along the centre of the horizontal plates. The joints of these angle-irons are also spliced with a patch of similar form. All abutting joints are accurately planed, as well as all sides of the sheets forming the web.

---

* From the 'Journal of the Franklin Institute.'

[illegible] ths and ⅜ths of an [illegible] width between joints. [illegible] covered by a batten, [illegible] by a double row of [illegible] each side, is a vertical [illegible] a projecting flanch of [illegible] rivets with the battens. [illegible] like a knee, and attached to the top and bottom members of the [illegible] way between these [illegible] on each side, of the [illegible] of the sheets, the ends [illegible] through the horizontal angle-[illegible] between the vertical member [illegible] at top and bottom.

[illegible] adopted for joining these web-plates to [illegible] bridges, is to place a T-iron on [illegible] head of the T forming the batten, and [illegible]. Having found these T-irons beginning [illegible] English bridges, owing to the weakness [illegible] the junction of the head and stem of the T, [illegible] T-iron of sufficient strength rolled in this country [illegible] from England at a moderate cost, I preferred [illegible] described above, which the event has proved to [illegible] stronger joint than the English one, and, at the [illegible] a cheaper one in our market.

As the tracks lie above the girders, ample opportunity is afforded for diagonal bracing between them, to maintain their perpendicularity and to check vibration. The ordinary mode of applying this bracing and that practised by English and Canadian engineers, is to attach at intervals of about 10 feet diagonal strips of plate iron to the vertical ribs, crossing each other like the letter X, and riveted together at their intersection. But the height of our girders being unusually great (7½ feet), as well as the horizontal distance between them (11 feet), these braces might flap and vibrate under express trains to such an extent as to bring undue strain upon their attachments and render them nearly useless. To obviate this, I formed each brace of two pieces of plate-iron, 6 inches wide and ⅜ths of an inch thick, connected at right angles to each other by a 1½ inch angle-iron riveted to each, giving a section similar to an angle-iron, 6 inches wide on each side of the angle. As the two members of the X are placed back to back, they are riveted together at their intersection. In order to get the strongest available attachment between these braces and the vertical ribs of the girders, that half of each brace which does not lie in a vertical plane was heated at the ends, and each end twisted 90°, allowing it to be attached to the ribs alongside the other strip, with the plane of which it here coincided. The result has been fully satisfactory, for the passage of heavy trains at high speed produces far less vibration than in many similar bridges which I have had the opportunity to examine in this country, and in England and France.

The rivets are, with a few exceptions, all of 1 inch diameter, being heated and headed in the usual manner. The rivet-holes are all drilled, being, as I believe, the first case of the kind in a work of this size. It can hardly be doubted that drilling secures a cleanness of cut, if not an accuracy of position, unattainable by punching. The drill neither disturbs the fibre of the iron near the hole, nor bends or stretches the plates like a punch: circumstances which often render it difficult for punched plates to be accurately fitted to each other, or to have that exact correspondence of holes which is indispensable to a first-rate joint.

This bridge is to be subject to a traffic of some forty-five trains daily, many of which trains weigh 400 tons. Previous to opening it to the traffic, it was tested as follows:—A large pile of iron rails was distributed over the floor, and a train placed on each track, weighing in all 159·3 gross tons. The deflections were carefully observed at the centre of each girder, the load then removed and a second observation taken, after which the load was replaced and again removed, with two more observations. The first loading produced a permanent set of 0·26 inch, a considerable portion of which may doubtless be attributed to the bearings on the abutments, where a white oak cushion, 4 inches thick, was interposed between the iron and masonry. The second loading of the bridge brought the girders down to exactly the same point as the first, the deflections being given below with the loads upon each girder. On removing the load, these deflections disappeared entirely.

	Load in tons.	Deflection in inches.
North girder	37·15 ...	... 0·39
Centre "	79·65 ...	... 0·33
South "	42·50 ...	... 0·45

The unequal distribution of the load upon the north and south girders was due to the different weight of the engines placed on the two tracks, a difference which was not intended, but which served to show how nearly the deflections vary with the weights producing them, proving the great uniformity of the workmanship in the three girders, while the rigidity of the centre girder is shown to be fully equal to its double duty. The materials used in this bridge were entirely of American manufacture.

◆

THE DENSITY OF STEAM AT DIFFERENT TEMPERATURES, AND THE LAW OF EXPANSION OF SUPERHEATED STEAM.*

We have already had occasion to bring under our readers' notice (vol. xxii., p. 365) the paper by Mr. Fairbairn and Mr. Tate, read before the British Association at Aberdeen in 1859. That paper gave an account of some experiments for ascertaining the density of steam at various temperatures, and of the approximate results which had up to that time been obtained. The experiments have since been carried further, and carefully corrected, tabulated, and analysed; and the present lecture records the whole course of the investigation, from the minutest details of the apparatus to the most general algebraic deduction.

It appears that scientific minds are strongly prompted to enact "laws" which may be conveniently embodied in mathematical formulæ. This kind of codification in physics has much to recommend it, not only to the judgment, but even to the fancy. It helps the memory by systematising observed phenomena. It enables us to tell very proximately (if not always accurately) what changes to expect under certain conditions. It affords the mind a final repose from ceaseless questioning or prolonged suspension of opinion. It enables us, in fact, to express the marvellous constancy of Nature's working in language that is intelligible and concise. Nay, we are even tempted to imagine that we are thus ourselves enacting laws which the elements are constrained to obey; and to regard our science as rather the mistress than the interpreter of nature. Nature however occasionally makes free to deviate from rules which have been sanctioned by the most eminent scientific authorities. We are thus at times (perhaps wholesomely) admonished to return to the humbler task of patient observation, until we can patch up our approved formulæ, so as to bring them into closer conformity with the real order of things.

A case of this kind has presented itself in the investigation of steam. What is known as Gay Lussac's or Dalton's law for determining the relation between the temperature and volume of gases was not only considered to hold good for all permanently elastic fluids, but was presumed to be applicable to steam. So convenient a decision was generally concurred in, and the concise and manageable formula, deduced on this showing from the experiments of Dumas on steam raised at 212°, had until lately been accepted, without further inquiry, as true for all pressures. The expansive power of steam under various conditions having however a special economic interest, the matter came in process of time to be more narrowly and practically gone into by some of our own countrymen. It was then found out that there was a considerable want of accord between the actual phenomena and the supposed law. In 1855 Prof. Rankine gave an entirely new theoretical formula, which has now been proved to give results remarkably near the truth. But until the time that Mr. Fairbairn took up the question, the law of the density of steam had not been sought out by means of actual observation.

The first and main difficulty was the devising an apparatus at once strong enough, and yet transparent where necessary; and the discovery of a visible test, sufficiently accurate and delicate, to determine the point of saturation. A very happy and elegant test was arrived at, depending on the different increase of pressure arising from vaporisation and from simple superheating. A full explanation of the principle of this "saturation gauge," as the inventor has named it, and a general account of the whole apparatus, will be found in this Journal, in the paper to which we have already referred (vol. xxii. p. 365).

---

* 'The Bakerian Lecture.—Experimental Researches to determine the Density of Steam at different Temperatures, and to determine the Law of Expansion of Superheated Steam.' By William Fairbairn, F.R.S., and Thomas Tate.—From the Transactions of the Philosophical Society, 1860.

Although a pressure gauge was connected with the apparatus, it seems only to have been consulted as giving a rough indication of the pressure. In each observation calculation was relied on for finding accurately both the temperature and the pressure of the steam at the point of saturation. The pressure was computed so as to agree with the results of the experiments of M. Regnault. In this respect therefore Mr. Fairbairn's researches must be regarded as based to some extent on those of M. Regnault; while as regards specific density and expansion they possess an original and independent value.

The results which are regarded as established by the investigation before us are—

"*First*, that the density of saturated steam at all temperatures, above as well as below 212° Fahr., is invariably greater than that which is derived from the gaseous laws; *second*, that the law of expansion of a perfectly elastic fluid does not hold strictly true for superheated steam. At the maximum temperature of saturation, and for some degrees above it, the rate of expansion of the steam greatly exceeds that of a perfect gas."

The widest deviation from the gaseous formula seems to occur at from 40° to 50° above the boiling point. Here the specific volume of saturated steam appears, from the diagram appended to the lecture, to be about 7 per cent. less than the formula referred to would make it.

Messrs. Fairbairn and Tate now substitute the following formula, as a faithful digest of the results of observation:—

"*On the Relation of Specific Volume and Pressure of Saturated Steam.*

Let V be the specific volume of a given weight of saturated steam at the pressure P, measured by a column of mercury in inches; then

$$V = 25{\cdot}62 + \frac{49513}{P + {\cdot}72}$$

and

$$P = \frac{49513}{V - 25{\cdot}62} - {\cdot}72."$$

As to the Law of Expansion of Superheated Steam, the results are given in the following table, from which the conclusions subjoined are drawn.

"*Table showing the Coefficient of Expansion of Superheated Steam.*

Number of Experiment.	Maximum temperature of saturation.	Temperatures between which the expansion is taken.		Coefficient of expansion of steam.	Coefficient of expansion of air.
1	136°·77	140°	170°	$\frac{1}{593}$	$\frac{1}{599}$
2	155·33	160	190	$\frac{1}{356}$	$\frac{1}{619}$
3	159·36	159·36	170·2	$\frac{1}{150}$	$\frac{1}{618}$
		170·2	209·9	$\frac{1}{624}$	$\frac{1}{629}$
5	171·48	171·48	180	$\frac{1}{200}$	$\frac{1}{630}$
		180	200	$\frac{1}{604}$	$\frac{1}{639}$
6	174·92	174·92	180	$\frac{1}{190}$	$\frac{1}{634}$
		180	200	$\frac{1}{637}$	$\frac{1}{639}$
7	182·30	182·3	186	$\frac{1}{230}$	$\frac{1}{641}$
		186	209·5	$\frac{1}{630}$	$\frac{1}{645}$
8	188·30	191	211	$\frac{1}{604}$	$\frac{1}{650}$
1′	242·9	243	249	$\frac{1}{517}$	$\frac{1}{702}$
4′	255·5	257	259	$\frac{1}{392}$	$\frac{1}{716}$
		257	264	$\frac{1}{606}$	$\frac{1}{716}$
6′	267·21	268	271	$\frac{1}{210}$	$\frac{1}{727}$
		271	279	$\frac{1}{640}$	$\frac{1}{730}$
7′	269·2	271	273	$\frac{1}{232}$	$\frac{1}{730}$
		273	279	$\frac{1}{351}$	$\frac{1}{732}$
9′	279·42	283	285	$\frac{1}{298}$	$\frac{1}{742}$
		285	289	$\frac{1}{358}$	$\frac{1}{744}$
13′	292·53	297	299	$\frac{1}{281}$	$\frac{1}{756}$
		299	302	$\frac{1}{638}$	$\frac{1}{758}$

"The results recorded in this table distinctly show that, for temperatures within about ten degrees from the maximum temperature of saturation, the rate of expansion greatly exceeds that of air, whereas at higher temperatures from this point the rate of expansion approaches that of air; thus for example, in Experiment 6, between the temperatures of 174·92° and 180°, the coefficient of expansion is $\frac{1}{190}$, that is, about three times that of air; whereas, between the temperatures of 180° and 200° the coefficient of expansion is very nearly the same as that of air, and so on in other cases. At temperatures somewhat removed from the maximum temperature of saturation, the coefficient of expansion in the high-pressure experiments is decidedly greater than that of air, whereas in the low-pressure experiments it does not greatly differ from that of air."

An intention is expressed of extending these researches to steam of very high pressure, and making a distinct series of experiments on the expansion of superheated steam. The ultimate results will then (as we infer) be reduced into the most comprehensive analytical form. Judging from what is already before us, they can hardly fail to be of very great interest and importance.

ARCHITECTURE AT THE ROYAL ACADEMY.

(Concluded from page 157.)

The sketch in Waltham Abbey, by Mr. Burges (673), showing the new east end as lately executed from his designs, deservedly finds a place "on the line;" it being on the whole, though small, one of the most remarkable and attractive pictures in the room. We refer more especially to the masterly skill which has infused the intensest of pictorial effects into one of the most shadowy of outlines, yet sufficiently detailed for its purpose. The indication of the stained glass in the windows is as perfect as it can be, nor is the general tone of colour less truthful and satisfactory. But without the help of the catalogue the subject might rather be imagined to be a foreign one, and not an English one only a dozen miles from the metropolis, so many and important are the alterations which the building has lately undergone. Without opening the question as to how far the architect of the new work may have been guided by existing ancient remains or by authentic documents, it cannot fail to strike any observer who is at all conversant with the characteristics of early French architecture, how closely Waltham Abbey, in its new aspect, presents marks of resemblance. Thus the rose window, and the arcade below (to mention nothing else), are essentially French, and being of the kind that Mr. Burges loves to reproduce, one can scarcely help surmising whether this partiality may not have had such an influence that the new work should rather be designated a substitution than a restoration.

In (674) Mr. Pollen gives a drawing of part of the archway of the new Oxford Museum as in process of execution, and if this drawing may be taken as fairly indicating what is being done, we regret that it should be (to our taste) so unworthy of the purpose. Novelty enough there is, truly, but of a very poor and unintelligible kind. The "Godolphin Schools" competition, which is pretty fairly represented in the Conduit-street Exhibition, reappears here in Mr. Mew's design (678), one of the best, in external appearance, that we have seen. The proportions are good, and the several parts well balanced. The building, we notice, is three stories in height, the walling being of light brick, banded with darker at intervals. Mr. Pearson's "Church to be built in London" (679), is unmistakably the same of which another exterior perspective appeared in the Architectural Exhibition which has just closed, and which we referred as an unusually meritorious design. The conception of the whole may be better realised by examining this drawing with the noble "interior view" exhibited in (681), simple, grand, and effective in the extreme. It is groined throughout in stone.

The recent completion of the Royal Horticultural Society's extensive and handsome buildings at South Kensington lends a present interest to the "Interior view of the New Council Chamber" which Capt. Fowke shows in (680), otherwise its very ordinary look would not provoke even an inquisitive glance. This chamber is capable of being used on state occasions for a vestibule to the gardens. Adjoining this picture is one which however is not likely to be overlooked—viz. Mr. Owen Jones' "Ceiling of Show Room at Mr. Hancock's, in Bruton-street, (685)—a perfect study of design and colouring, rich yet not gaudy. It is executed in that patent canvas plaster which Mr. Jones has previously employed so satisfactorily.

A by no means enticing scheme for covering the Royal Exchange area, with an elliptical roof over the upper order, is nicely shown by Mr. H. S. Legg in (688), and formed of course one of the competition series. The centre portion only of this roof is glazed, there being three panelled coffers on each side, proposed to be filled with colour and devices. This part of the design is not altogether satisfactory. A view of that great practical mistake, the Victoria Military Hospital, near Southampton (691), shows the building to its fullest extent, and to the greatest advantage, being both well drawn and well coloured, without betraying any trickiness. An equally large drawing is (691), which in these respects presents a contrast to the last, being decidly "got up" for effect, but not enough so as to conceal the real poverty of the subject, in spite of its ornate garnishings. It is somewhat ostentatiously styled a "Proposed Grand Hôtel de la Méditerranée, Cannes," and is by Messrs. T. Smith and Son.

Mr. Digby Wyatt exhibits two drawings—we might strictly say sketches—in brown ink outline (684) and (689). The former represents the "Gallery for Communication" lately erected in the great hall at Compton-Wynniates—being a highly-elaborated Perpendicular addition, carried on huge, ungraceful corbels. The cresting, too, is in questionable taste. The second drawing is a large perspective view, every stroke and line in which has been whimsically drawn by hand, and vaguely entitled "Original sketch for a Public Building"—query, the proposed New India House? But, be its purpose what it may (and it does not on the face of it give the least clue to a solution), we shall not, we think, run counter to public opinion in the wish that it may be permitted to remain on paper only. The prominent features are the large round towers which encompass the principal angles, and with their pyramidal roof give to the design a hybrid look neither of Scottish nor Continental extraction, but a strange compound of the two. Of the detail as proposed it is impossible to speak, it being so slightly indicated.

In (694) we are treated to a small and carefully delineated view of the new chapel at Exeter College, Oxford, which the artist, Mr. J. H. Le Keux, has also ably engraved. It shows the south side of the chapel, from indeed the only point whence the entire elevation is visible, and, by the close proximity of the buildings in the College quadrangle, accounts for the new building being much more curtailed in its length than it would probably have been had a more extended site been at the disposal of the architect. The "Manchester Assize Courts," now erecting from Mr. Waterhouse's design forms the subject of one of the most genuine architectural drawings in the room (696). We cannot however admire the sombre, heavy tone of the colouring. In this respect Mr. E. W. Pugin's admirable little drawing close by (697), has the advantage, for while there is sufficient detail shown to convey a fair notion of the design itself, there is just enough tint added to express the light-and-shade effect. The subject is the "New Exhibition Room recently erected at Oscott College, near Birmingham," and it is based on the characteristics of our "Perpendicular" style, but by no means slavishly followed. "Daylesford Church, Worcestershire" (698), by Mr. J. L. Pearson is, like his other pictures before mentioned, a subject divided between this exhibition and that at Conduit-street. The separation of drawings in this manner is much to be regretted, and it appears the less excusable, because, while leaving the matter in both cases incomplete, there does not appear to be any sufficient motive for so doing. The drawing before us shows, among other things, a very pretty lich-gate.

A view of a portion of the exterior of Hereford Cathedral, as recently restored by Mr. Gilbert Scott, is contributed by Mr. J. Drayton Wyatt, in (686). It combines, in a very picturesque group, three of the leading features of the exterior—viz. the North Transept (with its *single* aisle), the Central Tower, and the rich "Perpendicular" North Porch, each illustrating a different phase in architectural history. Mr. E. M. Barry's only drawing is of his New Schools in Endell-street, London (703), which are unquestionably among the best designed and most costly erections of the kind, and now so well known as to need no description here, though it may be mentioned that in this picture are ranged side by side the two gable ends, each so well studied, and so picturesquely varied that the contrast is at once perceptible, whilst another sketch shows the interior of one of the schoolrooms, ingeniously incorporated with the construction of the roof. Messrs. Prichard and Seddon's "Church at Newport, Monmouthshire" (704), has already been noticed and illustrated in our Journal for June 1860.

In four of the largest and most striking architectural drawings in the room (699—702), Mr. G. G. Scott exhibits "Views illustrative of Gothic designs for the Government Offices," including the perspectives as seen from Downing-street, the Park, and the internal quadrangle. In the principle of these is embodied the proposed new India House, which, as now arranged, is to front St. James's Park. Of the merit of this design and its adaptability to the requirements of its purpose it is not necessary again to speak, suffice it to add, that Mr. Scott appears disposed to battle to the last in carrying out his project, in spite of the adverse influences which have been brought to bear, and which at the present time still predominate. While on this subject we may call attention to (709), Mr. Green's "Design submitted in competition for the new Houses of Parliament at Ottawa, Canada"—a by no means prepossessing Classic design, not unlike in some particulars that submitted by the same gentleman in the Manchester Assize Courts competition.

Mr. David Brandon's contributions are, as usual, of domestic buildings in the late style of architecture which he especially favours; but this year his two houses erected in Worcestershire, as shown in (710, 711) have not much to recommend them. The church to be erected by him at Penboyr, Carmarthenshire (713), appears more promising. Of the new Offices for the Board of Works, in Spring-gardens, there is a careful drawing (714) sent by the architect, Mr. Marrable, but inasmuch as it has been pronounced a bad plagiarism upon Inigo Jones, it does not need comment at our hands.

Mr. Street is an exhibitor of only one drawing (718), a church now erecting at Bournemouth, which, in spite of the ability manifested in many of the subservient details, does not strike us as being, on the whole, one of his happiest efforts. Much as we delight in the broken outlines and picturesque groupings which Mr. Street generally secures, in the present case these appear to be so abundant as to produce a lack of unity. The steeple is a very original conception, having evidently been minutely studied out, and with great success. The next in the catalogue is Mr. Blomfield's "New Church at Tor Mohun, Torquay" (719), which also betokens considerable originality and picturesqueness; the latter quality being attributable in part to the irregular nature of the site, and which the architect has judiciously turned to good account. Some other of the designs for this competition (which was a limited one) were to be seen in the late Architectural Exhibition.

The Almshouses which Mr. W. Webbe has just completed at Rochester form a very effective subject in (908), and are worthy of the designer of the Printers' Almshouses and of the Royal Dramatic College. Mr. Herdman's "View in Cartmel Priory Church" (890), will be noticed with interest; also Mr. W. J. Boddy's "Chapel of St. Edmund, Westminster Abbey" (891). We are sorry we can find nothing to commend in (906), the church now erecting by Mr. Ashpitel at Ripple, near Deal, which is of the most commonplace kind; nor are Messrs. Aitchison's "Schools at Barking" (907), in the best of taste. The utmost praise must however be bestowed upon Mr. E. Falconer's "Oriental Sketches" (921, 922), which are, as usual, models in their way. They represent two mosques, one at Mylassa, and the other at Nicæa, in Asia Minor.

ACCIDENTS ON RAILWAYS.

THE periodical reports of the inspecting officers of the Railway Department on the accidents that have occurred on railways are extremely valuable records, not only because they afford the most reliable information respecting the causes of such accidents, and therefore point out the means of guarding against similar recurrences, but they serve also to remind directors of their duties to the public, and urge them to adopt the precautions which such disasters show are required for giving to railway travelling the security of which it is capable. The reports for the last six months of 1860 and for the two first months of the present year refer to fifty-four disasters, some of which were attended with fearful loss of life; and though called "accidents," the majority of them were caused by carelessness or want of proper precaution, to which such a term is scarcely applicable. Of the fifty-four so called accidents, twenty-nine were occasioned by collisions, which in almost every case may be attributed to culpable carelessness or inattention; nine were occasioned by the engines or carriages leaving the rails, in consequence generally of defective construction or imperfections in the machinery; eight were caused by the breaking of tires; only one by the breaking of an axle; the fracture of a wheel occasioned one accident; and in two other instances the cast-iron girder of a bridge broke, and a wooden viaduct gave way. Those accidents that arise from defective construction, either of the permanent way or of the locomotive mechanism, generally stand apart from those occasioned by carelessness and mismanagement; and the investigation of their causes is the most instructive, as it affords the means of improving and of perfecting the mechanical arrangements of railway locomotion.

We shall first notice those accidents caused by the engines leaving the rails. They were occasioned in two instances by the tightness of the gauge at curves on the line; one of them on the London and Blackwall Railway, the other near the Primrose-hill tunnel, on the North Western line. Capt. Tyler, who reports on the first, observes: "I attribute the present accident to the fact of the gauge not having been sufficiently easy on so sharp a curve. In such a case a curve may be used for a length of time without accident, but a carriage may mount the outer rail once in a way." Col. Yolland, who investigated the second case, observes: "I am satisfied that the tightness of the gauge at the commencement of a sharp curve, without any surface elevation of the outer rail, was a sufficient cause for the wheel mounting." It must be stated however that in both cases there were points where the carriages got off the rails.

The state of the permanent road, which was not sufficiently consolidated before the trains passed over it, is the assigned cause of two other instances of the carriages leaving the rails, both on the South Western Railway. In another case on the same railway a broken rail was the cause. The rail was a turned one, and Capt. Tyler objects generally to the use of turned double-headed rails. "There are," he says, "disadvantages attending the use of rails in this manner which more than counterbalance any advantage in economy that may be obtained. The upper surface of the rails, after having been worn out or injured, does not fit well into the beds of the chairs; the lower surface has always been more or less damaged and rendered uneven by pressure against the chairs; and the rail itself, after having been subjected for a series of years to strains, and having perhaps received a *set* in one direction, is the more severely tried by being exposed to strains of a new description, and in an opposite direction." The want of proper signalling occasioned one train to run off the line at a place where the plate-layers had removed two of the rails; and in the two remaining instances of such occurrences they are attributed to the use of an improper engine for the work, and to the breaking of a turn-plate, which was made of improper materials.

In considering the class of accidents caused by the fracture of tires, both inspectors refer again and again to the imperfect and dangerous method of fastening on tires with rivets, for in nearly all instances of fracture they occurred at the rivet-holes; and both inspectors recommend the adoption of some one of the modern improvements for the fixing on of tires without the necessity of weakening them by making rivet-holes. Several drawings of the various plans contrived for that purpose are given, and Mr. Beattie's method is mentioned approvingly by Capt. Tyler and by Col. Yolland. On this important point we quote the following remarks by Capt. Tyler, in his report of an accident that occurred on the Chatham and Dover Railway, near Sittingbourne, on the 4th of January last, and we give also diagrams of Mr. Beattie's and of Mr. Burke's method of fastening tires, which are particularly referred to, and of improvements suggested by Capt. Tyler.

> "There are various methods, of which some have been in use for several years, whilst others are of more recent date, for avoiding the weakness thus arising from rivet-holes in the tires, for securing them to the rims of the wheels in a more advantageous manner, and for preventing them from separating from the wheels in the event of fracture. I had occasion to refer to this subject in a report upon an accident which occurred in the early part of last year, at Tottenham; and I then forwarded diagrams of a system of fastening that had been adopted with these objects upon certain railways. I now beg to inclose drawings of a number of other modes which have been employed; and I would observe, in doing so, that they merit the best attention of the locomotive and carriage superintendents of all railway companies; because the principles upon which they are designed are calculated, when properly carried out, to provide completely against the danger which is now so much experienced—and particularly in seasons of low temperature—of accidents such as that on which I am now engaged in reporting, occasioned by tires opening out or flying off when they are fractured, from the wheels of locomotive engines and tenders and of railway vehicles.
>
> It will be observed, on an inspection of these diagrams, that in all the different methods which they represent the tire is dovetailed to the rim of the wheel; and in all but one there is no weakening of the tire by rivet or other holes bored in to secure it to the rim. Mr. Beattie adopted this method in the case of engine-wheels, under the belief that the weights which the tires of those wheels had to sustain rendered it necessary to give the rim as wide a bearing upon them as possible, and undesirable to diminish that bearing for the sake of obtaining a fastening at the interior side of those wheels, such as he had applied to carriage-wheels.
>
> . . .
>
> Mr. Beattie accomplishes this by grooving the tire, as at A, Fig. 3; by inserting wedge-shaped keys at intervals round the circumference, B, B, B, Fig. 1; and by hammering down the portion C (Fig. 3), upon the keys thus inserted. Whilst employing this system on the Great Northern Railway very extensively, Mr. Sturrock has found it necessary to place a key on each side of the weld of the tire, as an additional security against its flying, in case of fracture on account of a defective weld.

FIG. 1.

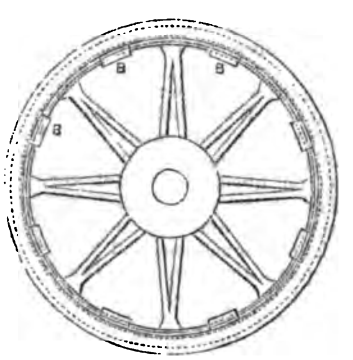


FIG. 2.

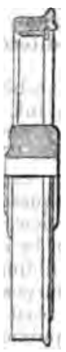
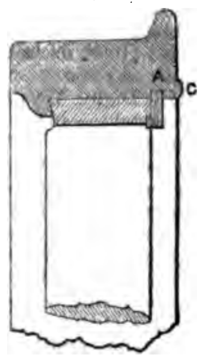


FIG. 3.



> It cannot be considered that the tire is so firmly secured to the portions of the rim between the keys, as when a more continuous means of fastening it is employed. In a method which he has proposed for engine-wheels, for reasons which I have already given, Mr. Beattie has secured the outer side of the tire by means of a groove fitting on a notch in the rim of the wheel, and has attached it, near the inner edge, by bolts screwed into it from the inner surface of the rim, and inserted at frequent intervals.
>
> . . .
>
> Mr. Burke's tire is rolled out into the shape shown in Fig. 6, and is welded, turned to a true surface, heated, slipped on to the wheel, and allowed to contract in the usual manner. It is then turned over; the portion M is heated to a red heat, and that portion is hammered down against the rim all round its circumference. All of these methods of fastening tires are superior to that which is now commonly adopted, and any one of them may be considered, when the materials are well selected, and when careful workmanship is employed, to afford a high degree of security. That which is shown in Figs. 4, 5, 6, is perhaps the most simple, and the most likely to come into general use. The disadvantage that it would present to some eyes, in the impossibility of taking it off the wheel for tightening or repair, after it is once fixed on, and replacing it in its original condition, is by no means so serious as it might appear to be at first sight. Either security must be more or less sacrificed when this condition is maintained, or else some more complicated arrangement connected with the rim, such as those of Mr. Mansell and Mr. Brotherhood, must be employed. But in truth, the cases in which repairs requiring the removal of the tire become necessary, when good wide tires are carefully attached to well-constructed wheels, are so rare, that they may fairly be left out of consideration; and a tire which has worn slack and is re-shrunk on the wheel will almost always become slack again within a short period. Such an operation is hardly worth performing; and when a good tire is securely fixed in the first instance, by means of an efficient continuous clipping attachment, it will then be

FIG. 4.

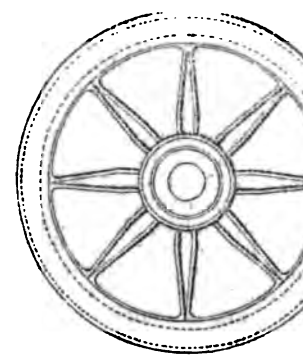
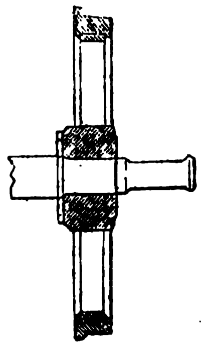


FIG. 5.



worn out to the thinnest state in which it is fit for use, without any apprehension of danger in consequence either of its fracture or of its slipping off the wheel.

The real disadvantage of this mode of fastening appears to me to lie either in the liability to an imperfection of fit between the rim and the tire, or of a want of parallelism in the dovetail surfaces in the first instance; or else in an alteration of the shape of the tire, by spreading or otherwise, from wear and tear, which must always become greater as the tire becomes thinner, and which would therefore render the fastening less and less secure, at a time when it was more and more necessary that it should be efficient. To prevent the possibility of such defects I think that a modified mode of fastening might be adopted, such as I have shown in Figs. 7 and 8, which would be well adapted for all wheels, would give increased security at all times, and remain efficient up to the last, becoming indeed more secure as the tire got thinner and hollow from wear. In the application of this arrangement, the tire would have to be grooved at O, Fig. 7, when it was turned to its proper size, and the rim of the wheel would have a notch on each side of it. The tire should not be in too heated a state when the wheel is slipped into it, as the rim would not in that case penetrate into the recess at O; but it has been found by experience that a sufficient heat may be imparted to the tire in shrinking it on, without any difficulty of slipping it into a recess of suitable dimensions being encountered. Fig. 7 exhibits the condition that would exist between the wheel and tire when the wheel is first inserted, and Fig. 8 the finished tire, after the inner edge at Q is hammered down upon the rim.

FIG. 6.

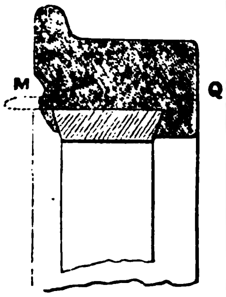


FIG. 7.

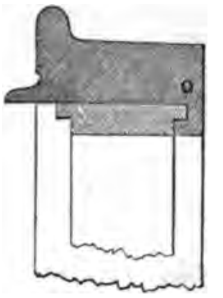
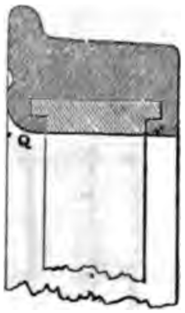


FIG. 8.



Although there is greater fear in general with regard to a slack tire, or a loose tire, or a broken tire, the most dangerous tire of all is that which has been shrunk too tightly on to the wheel, and whose state of tension renders it ready to fly upon any violent blow being administered to it by a bad joint, or an uneven crossing, in the ordinary course of traffic. This is the sort of tire that yields the clearest ring to the hammer of the carriage examiner, and that inspires him frequently with the greatest degree of confidence; but this is the tire that ought in reality most to be dreaded; and this is the description of tire that occasioned the present accident.

But even when a tire has been placed upon the wheel in a condition of too much strain, there ceases to be danger when it is secured to the wheel in some manner such as I have now indicated, in which it is prevented from separating from the rim, or, as it is termed, from flying, when fracture takes place."

In reporting on this class of accidents the inspectors comment in severe terms on the neglect of railway directors to provide the means of security which fatal experience has shown to be necessary. Col. Yolland, in reporting on an accident which occured on the Great Western Railway on the 14th of January thus gives vent to his indignation on the subject:—

"There is not the least difficulty in introducing such an amount of break power as would have enabled the driver to stop in less than one-fourth of that distance; but the executive of the Great Western Railway Company, like the executive of most other railway companies, appear to slight warnings of this kind, and make no alteration in their system, and seem to prefer to run the risk of having to pay enormous sums of money in compensation for accidents and damage to rolling stock than to attempt any improvement in this respect.

Had this fracture of the tire taken place at night, the travelling porter could not have seen that anything was wrong; no passenger in the carriage would have had any chance of making it known to the guards; and supposing that to have been effected, it is doubtful whether the guards could have attracted the driver's attention, and the consequences might have been most lamentable.

I am afraid it is hopeless to expect any improvement, and I know that it is useless for an inspecting officer to continue to call attention to it.

If warning were taken from accidents of this kind occurring, not only on one but on most of the railways in England, improvements might be introduced similar to those which have on some lines been adopted with reference to the mode of fixing the tires on wheels; but with the studied persistence in such a vicious system, the reports of the inspecting officers might almost as well not be made, as they appear to serve no other useful purpose than to give the sufferers in railway accidents or their representatives a clue on which to base their demands for compensation."

The necessity of providing a communication between the passengers and the guard, and between the latter and the engine-driver, is often enforced; for on many occasions, had such a means of communication existed, the disasters that ensued might have been avoided by timely notice; and Col. Yolland says: "It is to be regretted that the law does not make some one criminally liable for such neglect." It must be observed that all the fractures of tires noticed occurred during the severe frost of last winter, which contracted the metal and made it less capable of bearing a blow.

The accident arising from the fracture of a cast-iron girder occured on the Midland Railway, on the 26th of September, at a bridge near Ambergate. A heavy goods train was passing over the bridge at the speed of about 14 miles an hour, when the engine-driver found that the wheels of the engine had been thrown off the line, and that only two of the waggons remained attached to the tender. He had no idea of the cause of the accident at the time, as the roadway did not fall in. The cause of the fracture is thus explained by Capt. Tyler.

"The bridge that thus gave way was to all appearance substantially constructed, with six cast-iron girders upon masonry abutments. Two girders carried each line of rails, and the other two supported the parapets. It was originally built some twenty-three years ago; but in the course, I believe, of last year, the main girders were placed rather farther from each other than they had previously been, as it was found that they were occasionally struck by passing vehicles. The platform which was then added to them for carrying the permanent way consisted of old rails which had been taken up from the main line, of the description known as Barlow rails, laid transversely, and covered with asphalte and about 5 inches of ballast; and the wooden sleepers, on which the rails and chairs were supported, rested in this ballast, also transversely, in the usual manner. The Barlow rails lay on the inner flanges of the main girders, and were not as accurately fitted as they might have been, with a view to their taking a bearing close to the middle webs of the girders. The weight of the rolling loads which passed over them was not distributed upon the Barlow rails, except partially, through the medium of the asphalte and ballast, but it was carried principally by those particular Barlow rails over which the sleepers were placed. The main girders were not bolted together, but were retained in their position, partly by their own connection with the abutments, and partly by the stone flagging which lay between them and the outer girders on each side. The two middle girders were close together, and the distance between each pair of girders carrying the railway was rather more than 10 ft., the two outer girders having been 2 ft. 6 in. from the edges of the rails next to them. The girders were 29 ft. 2 in. long, with straight tops, and they covered a clear span of 23 feet. Their depth was 2 ft. 0¼ in., the area of their top flanges about 19½ inches, that of their bottom flanges about 40 inches, and that of their middle webs about 50 inches. The breaking weight of each of these girders, supposing the metal to be sound, may be estimated at 90 tons placed in the centre; and the ultimate strength of a pair of these girders, under a load equally distributed over them, at 360 tons. The heaviest engines in the possession of the Midland Company—one of which was attached to the train in question—weigh, when in working order, 31 tons, and their tenders 18 tons, making a total weight of 49 tons, upon a wheel-base, measured from the leading axle of the engine to the trailing axle of the tender, of 36 ft. 3 in. Of this weight however the engine only could be upon a span of 23 ft. at one time, because the distance from the leading axle of the engine to the leading axle of the tender measures 24 ft. 9 in. It may therefore be considered that the factor of safety in this bridge, if the girders had been sound, would have been about 9 as against the maximum total load, or about 11 as against the greatest rolling load, after first deducting three times the weight of a proportion of the superstructure from the ultimate strength of the girders. The girders are in fact heavier than those which are frequently employed in ordinary railway practice for similar spans at the present day; and the proportion borne by their top to their bottom flanges is greater than, as is now well understood, is necessary. The girder which failed was on the north of the down line from Derby to Normanton; and it gave way at a distance of 3 ft. 8½ in.—about a ninth of the span—from the west abutment of the bridge. It would, if sound, have been considerably stronger at this point than at the centre; but it appears to have been seriously defective. Of the half side of the bottom flange an area of 6¼ square inches only was sound; and this was the side on which the Barlow rails rested, and on which therefore the permanent way was supported. It is impossible to say whether this defect existed to the same extent when the girder was originally cast, or whether it was comparatively small in the first instance, and has since increased in the course of traffic."

The wooden viaduct that gave way, though without doing any injury, is on the Whitehaven Railway, and it had for some time been suspected to be in a defective and rotten condition. Capt. Tyler objects to the employment of timber for viaducts, which he says should only be done when great economy is required in the original construction.

The causes of the twenty-nine disasters that arose from collision may be summed up to have been carelessness and neglect, more or less culpable. Five of them happened to excursion and to special trains, which are at all times dangerous, and in one instance two excursion trains came into collision with one another, on the Lancashire and Yorkshire Railway, owing to the breaking of a coupling chain as the train in advance was ascending an incline. The want of additional break power to bring a train more quickly to rest when an obstacle on the line is visible, is frequently mentioned with strong condemnation by the inspectors; and we will conclude this notice of their able reports with the following extract from Col. Yolland's report on the collision of the two excursion trains, in which he points out the increasing necessity of additional break power, in consequence of the steep inclines now frequently adopted in the construction of railways.

"There is yet one other point which more particularly concerns the duties of the inspecting officers, and which should in my opinion be brought under their notice. The length of railway lines on which steep inclines occur is increasing every year; and as the legislature has not deemed it expedient to intrust the Board of Trade with any power as regards the mode in which traffic shall be conducted, but confines its interference to unopened lines of railway; and as railway companies have very generally disregarded the recommendations made from time to time by the Board of Trade on the subject of increasing the amount of break power, on the establishment of a communication between guard and driver, and on the placing of a break at the tail of every train, &c., it remains to be considered whether the inspecting officers, looking solely to the question of the public safety, should not, when inspecting new lines of railway, decline to sanction any stations which are placed upon inclines, on which carriages will travel by the force of gravity alone. Accidents from the breaking away of carriages, or the separation of trains into two or more parts, are very much more numerous than the public are aware of. Those which are reported to the Board of Trade do not probably amount to one-tenth of those that occur: because, happily, in the greater portion of cases they are not attended with serious injury to life or limb. I know, but not officially, of instances where vehicles have broken away, and been caught by sending an engine after them on the same line, only a very short distance in front of a passenger train; and of others where—by the presence of mind of station-masters and pointsmen—descending waggons have been turned off the main line into a siding, and been destroyed. In the course of two years, and in two accidents alone, 25 persons have been killed and 127 injured, from the construction of stations on inclines; and I submit that such a sacrifice of human life, and such an amount of injury to persons, should be held sufficient to justify any inspecting officer in declining to pass a station on an incline on which carriages will descend by the force of gravity. And with their lordships' sanction, I think that notice should be sent to all railway companies engaged in making new lines, if the other inspecting officers agree with this view of the subject, that stations on such inclines could not be passed in future."

Appropriate to the report on railway accidents, we have had submitted to us drawings and descriptions of Mr. Wright's "Bed-plate Iron Safety Railway," by which carriages would be prevented from running off the rails by means of a "safety-kerb," fixed by the side of the rails, and several inches above its upper surface. The breaking of wheels, axles, or tires, might also be rendered harmlesss by a "life-guard" or fixed break, which would drop on the kerb and support the carriages, and at the same time effectually retard the motion. There can be little doubt that by a contrivance of this kind many accidents might be prevented, but the cost would be a barrier to its adoption. It is estimated that the expense per mile of a single line would be £2428, and that the application of the safety-kerb to wooden sleepers could not be effected for less than £1127 per mile. There is little hope therefore of the adoption of Mr. Wright's contrivance generally, though on bridges, embankments, viaducts, or sharp curves, it could be introduced with advantage, without great expenditure. It is worth consideration, however, whether the plan of the safety-sledge might not be applied to ordinary rails, so that when an axle or wheel breaks the carriage might drop a few inches safely on to a fixed break, instead of being turned over, with great danger to the passengers and injury to the other carriages in the train.

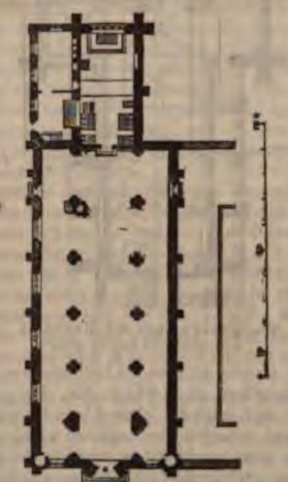
REVIEWS.

The English Cathedral of the Nineteenth Century. By A. J. B. Beresford Hope, M.A., D.C.L. With illustrations.—London: John Murray. 1861. 8vo. pp. 282. [Second Notice.]

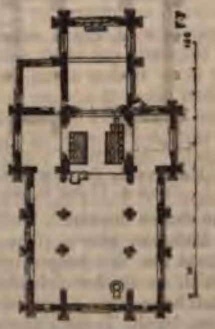
In our previous notice of Mr. Beresford Hope's book we referred to the contents of the earlier portion of the volume, and laid before our readers specimens of the illustrations. Some additional illustrations we here introduce, with their descriptions from the volume itself.

"The first church to which I shall call attention is St. Ninian's Cathedral, erected for the use of the Scottish Episcopal Church in the flourishing town of Perth, by Mr. Butterfield, designed in a somewhat severe variety of Middle Pointed. The choir, transepts, and one bay of the nave, were consecrated in 1850, and so have been in use for about ten years. The rest of the building, with a trifling exception, has yet to be built. This plan carries simplicity almost to an excess; for example, the transepts are not apparent in the plan, owing to the manner in which the nave arcade has been handled.

Of a much later date is the cathedral of Kilmore in Ireland, for the united dioceses of Kilmore, Elphin, and Ardagh, due to Mr. Slater.



Plan of Perth Cathedral.
75 feet to inch.



Plan of Kilmore Cathedral.
75 feet to inch.

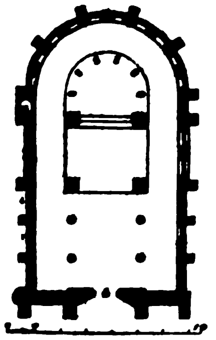
This church, in Middle Pointed, was consecrated in its completed form in July 1860, by the present energetic diocesan, Bishop Beresford, who carried it through, both as a work practically wanted and as a memorial to his famous predecessor, Bishop Bedell. It is, as will be at once apparent, of very small dimensions in proportion to its ecclesiastical rank, but yet it aims with much success at the cathedral character, in all points except the inferior elevation of the transepts. It moreover possesses the practical merit of having been entirely built according to the original plan. I have heard with much pleasure that the Bishop of Kilmore has already seriously talked of enlarging it, towards the west, by the addition of two bays."

It is almost to be regretted that fuller illustrations are not given of one of the most interesting of modern churches—the Memorial Church at Constantinople. The plan actually to be carried out of Mr. Burges, and that of Mr. Street, are indeed here, but of neither is any elevation or section furnished. Perhaps however as this church is to be rather a monumental edifice than anything else, and is certainly not built with the idea of erecting Constantinople into an English episcopal see, the author has shown his consistency in adhering to his subject, and giving the fullest illustration of those buildings which are most truly cathedrals.

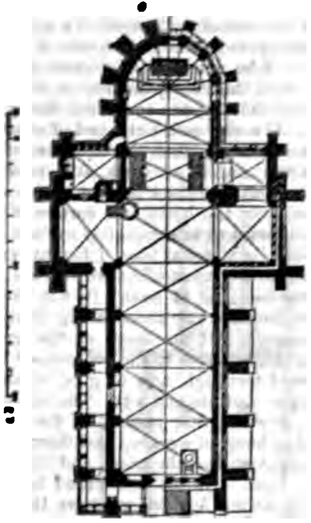
"I must still detain my readers in southern climates while I introduce the two next plans to them. It has not, I hope, faded out of their recollection that on the conclusion of the Crimean war the religious feeling of the English people led them to the determination of sanctifying the peace by the erection of a memorial church at Constantinople. The appeal was made under distinguished auspices, and liberal subscriptions flowed in. The choice of the architect was made by unlimited competition. Although personally concerned both in drawing up the terms of the competition and in the adjudication of the prizes, I may I trust be forgiven for appealing to this competition as standing out in favourable contrast to others of a more imposing character, and for a more magnificent stake, which have occupied public attention during the last few years. . . . .

The character of the structure was to be "monumental," and it is in this character of "monumental" that I offer the plans of the church as modified by Mr. Burges, in a somewhat reduced form, and of the design which won the second prize, by Mr. Street, in its original condition. With all their high merit, these designs are so different in their conception that I can notice each without a reference to the other.

Mr. Burges's idea, embodied in a style combined of Italian-Gothic and Early French, seems to have been to reproduce the general cathedral or minster type of the Continent upon a small scale, and yet with such simplicity of plan as to obviate the risk of pettiness and confusion. In this he was very successful. The plan, as originally drawn, comprised a groined nave of three vaulting and of six arch bays, aisles to the entire building, and transepts, and an apsidal choir, comprising a distinct bay, leading up to the circumambient aisle encircling the apse. In section the church displayed, besides the main arcade, an arcaded triforium, and a clerestory above. The chief artistic effect after which Mr. Burges aimed was the perspective of the east end, with its 'chevet'—a feature which he further defended on practical considerations, about which I shall have more to say hereafter. The work could not be undertaken at once, for the Turkish government—always tricky and perfidious—did not really look upon it with favour. At last, however, the zeal, kindness, and ability of Lord Stratford de Redcliffe overcame all obstacles, and a magnificent site in the most conspicuous part of Galata was presented to the future church by the Sultan. In the meanwhile trade matters at Constantinople had resumed thir normal state, and uncertain prices made timid contractors. Accordingly Mr. Burges recast his plan upon a diminished scale, substituting a barrel for a groined roof, reducing the nave to three bays in length, abridging the breadth of the transepts, curtailing the length of the eastern limb, and combining the triforium and clerestory on the same principle as at Brisbane, but retaining the chevet. In this form the building presents indeed but moderate dimensions, but yet is invested with a peculiar dignity of plan, well suited to a "monumental" church; to a structure that is, which, like the St. Chapelle, or Merton Chapel, Oxford, possesses attributes which raise it above the general run of parish churches, and justify it in borrowing some of the forms and stateliness of a cathedral.



Mr. Burges' Plan, Memorial Church. 75 feet to inch.



Mr. Street's Plan for Memorial Church. 75 feet to inch.

Mr. Street's design, which appears in all the grandeur of its original dimensions, is composed in an Italianising translation of Middle Pointed, and will at once recal the plan of Alby Cathedral, although, unlike Alby, it adds the grandeur of transepts, while it dispenses with that ring of chapels which have no use in the English ceremonial. Aisles are wanting, and with them, of course, the triforium and clerestory properly so called, and so the whole church is one vast vaulted area, like King's College Chapel. At the same time, as the left-hand moiety of the plan indicates, Mr. Street provides a low external cloister all round the nave for purposes of air and communication; and as we see, to the right he pierces the wall at the window level for a narrow triforial gallery, with glazed windows on the external plane, and window-like openings, mullioned and traceried, to the church. I must repeat, respecting this design, what I have already said of Carpenter's Colombo design, that it would be a great misfortune to art if a work of such merit were to be forgotten in its author's portfolio. I do not know whether Mr. Street would agree with me, but I think it would be admirably suited for the cathedral of some northern city, where the winters are long and sharp—Ottawa for instance, or one of the prairie cities, should the episcopal church of the United States find itself strong enough to raise cathedrals. Those precautions which Mr. Street with great forethought has taken against the inconveniences of over-heat, would equally serve to ward off the inclemency of the biting frost."

The chapter—or rather the series of chapters—in which that portion of the book is included which has now passed under review, concludes thus: "Having now given reasons why the increase of cathedrals is desirable, having treated of the style in which it is expedient to build them, and briefly indicated their general plan, and having shown how far practice has proved them possible, I shall in the following chapters proceed to consider the various portions of the building as they successively present themselves." This part of the subject occupies the last five chapters of the work; and is commenced by an examination into the plan of cathedral churches, which not unnaturally leads to a discussion of the question of choral and musical services, their present popularity, and the appliances they require. As this is a feature of our public services which has become increasingly popular of late years, it claims to receive marked attention in the cathedrals of the present or the future.

Next follows a discussion of the question of basilican churches, and the nature of their arrangements, and the reasons which led to their original adoption and which would render them now unsuitable. This is perhaps the most able and interesting portion of the book, and treats a difficult question with breadth and intelligence. The differences between the Christian communities of early Rome and those of the mediæval period are first shown, and the fitness of the churches raised in each age for the wants of that age is then lucidly demonstrated, while it is shown clearly that to go back to the earlier form would little suit the arrangements of the modern Anglican church, more directly descended from, and in its ritual more closely allied to, the mediæval than the ancient church. The great difference lies in the superior prominence given in the basilica to the episcopal throne, and the seats for the assessors, which here form the central and crowning feature, and in the front of which stands the altar,—a prominence surrendered early in the middle ages, and replaced by the exaltation of the high altar, while the bishop's throne and canons' seats occupy the sides of the choir. The multiplication of altars, however, which was the most distinctive of all the features of a Romish cathedral, cannot possibly be copied in a Protestant church; and in the opinion of many the great prominence of the one altar is carried too far. Without attempting to enter into theological and ecclesiastical discussions, we cannot forbear remarking how near many of the bodies of Presbyterians and other dissenters have approached to a return to ancient basilican arrangements. The architect who can succeed in persuading a congregation of dissenters to build a place of worship thoroughly in the spirit, and embracing most of the actual forms, of the early Christian basilica judiciously modernised, will produce an architectural work equal to many a Gothic church or even cathedral, alike for its commingled novelty and its venerable prescriptive antiquity, its suitability to the feelings and requirements of a large part of the Christian world in the present day, and its connection with the traditions and customs of the early Church.

A practical chapter or two follow, which treat of the various parts of a cathedral, its painting and its sculpture, concluding with suggestions as to the modes of dividing existing dioceses and creating new sees; on this latter subject we do not intend to enter, nor will our limits permit us to say much about the other topics, which indeed we advise our readers to study for themselves in the book. The advocacy of certain unusual forms of plan, and the decided preference expressed for groining in stone or wood, or for some sort of ceiling in preference to an open roof in cathedral and other large churches, are points especially deserving notice.

When it is remembered that Mr. Beresford Hope was (as is stated here) mainly instrumental in promoting the employment of gorgeous polychromatic decoration in the church in Margaret-street, his observations on that subject will be read with interest. We subjoin an extract.

"The application of coloured material—marble, brick, and so on—both to the main features and the decorative details of buildings, is every day coming into vogue with a fulness which never could have been compassed while the steam-engine was still unknown. A few years since those who, like myself, were in the van of this movement for 'polychromatic architecture,' or for 'constructive coloration' (according as the question was viewed from the one side or the other), had to give our reasons, and had to prove our opportunities: now we are almost overwhelmed with success. Architects—Gothic, Italian, 'Victorian' (sacred and profane)—are all vieing with each other who can produce most red brick, and yellow brick, and black brick, most granite, serpentine, and encaustic tiles, all over their buildings; while quarries at the Lizard Point and at Peterhead have become lucrative properties. It is well that it should be so. There may be here and there exuberance, if not extravagance; but this is only the natural recoil from the *malebolge* of stock-brick and cement in which we had been so long wandering. I have almost now to address a caution in another direction, and to remind the man who is planning a Gothic interior that there is such a thing as a paint-pot, and that, while constructive coloration may rightly be his staple, there were brave men of old who have left immortal achievements traced by their brushes in the higher branches of pictorial decoration."

In taking leave of this admirable volume we would remark, that the occasions on which men of great wealth and great taste give us illustrated books on architecture are so few, that we could have wished this opportunity had been seized for marking a new era in the history of English wood-engraving. Our readers have had an opportunity of judging of the excellent nature of the matter illustrated and of the quality of the woodcuts: that quality is very good, but recollecting the best illustrations in the works of Viollet-le-Duc, and some other French authors, and aware that it is only a question of expense whether they shall not be surpassed by the works of native artists, we should be glad when a second edition is required to see the opportunity seized to render a book by so distinguished an author—and a book, too, so sure to have a large circulation—unquestionably an advance with respect to its woodcuts, not only upon all previous English, but upon all French books of the kind. We would heartily express our sense of the many and great excellences of the work, and most confidently recommend it to our readers.

Healthy Moral Homes for Agricultural Labourers, &c. By C. V. Bernard, a "Practical Workman" of Forty Years' Experience. London: James Ridgway. 1860.

In reviewing an elegant book on cottage-building by Mr. Vincent (see vol. xxiii. p. 241), we pointed out the necessity of a much cheaper build than that gentleman proposed or attempted, before good could accrue to the agricultural population at large. The work before us is intended to supply this desideratum, but most unfortunately cannot be said to have more than half attained its aim; for if the author has understood what was to be done, and has by economical arrangement and the employment of cheap materials, gone far towards attaining his aim, he has on the other hand shown that, notwithstanding the "forty years experience" of which he boasts, and the results of which he offers to the public in the form of "practical advice given on all matters connected with buildings of every description," adding, "we can provide working plans, elevations, and sections, with detail drawings and specifications, at a very moderate agreed price"—nothwithstanding all this, and much good sense and shrewdness shown in the observations the book contains, he is anything but a trustworthy guide, and the book, if depended upon, cannot fail to lead to disappointment. The fact is this: very good plans and very cheap materials are pointed out in the work, but the price at which the various designs could be carried out is rated so low, and calculated so loosely, that in our opinion it would be difficult to build anything durable and habitable for from one-third to one-half as much again as the sums named. This perhaps affords the reason why the price charged for professional services is to be *very moderate.*

Our professional readers, and all acquainted with building, can test the truth of these observations, which we feel unwillingly compelled to make, if they will, as we have done, carefully check both the measurements and the prices of one of the bills of quantities appended to the designs. They will however find the book in other respects suggestive: the plans are all compact and economical; perhaps the rooms are rather too small, but it is of so much importance to get the right number of rooms in a cottage, that of the two evils we consider small rooms more endurable than not enough of them. A desirable alteration would be in several instances to substitute a straight staircase for one with winders: it is necessary to construct cottages so that a coffin can be brought down the staircase in the event of a death occurring; and this, obvious as it is when pointed out, is constantly overlooked in the erection of such dwellings.

Some economical modes of construction are pointed out, but we think in one or two cases that expedients neither quite durable enough nor quite substantial enough for the purpose have been resorted to: this is especially the case with the roofing, which it is suggested may be of asphalted felt on boarding. The roofs so made are not bad as coverings, but they require re-dressing every year, or they will decay, and the dressing besides being an annual expense, brings a very offensive smell with it, which lasts for some time.

Some very apposite extracts from writers who have given attention to the subject are introduced; and, as we have already stated, the practical observations in the book are many of them valuable, as for example the following:—

"The children of a labourer rarely remain at home after they are fourteen or fifteen; but the separation of the sexes in their sleeping-apartment is quite as proper for them as for the landlord's sons and daughters. The girls' bed-room is larger than the boys' bed-room, so as to be occasionally used as a work-room for the girls. Every cottage should possess the convenience of a scullery or back-kitchen, so that it may not be a matter of necessity that the perpetually recurring washing, with its accompaniment of damp and steam, should take place in the presence of the assembled family. Foundations to be laid on a dry soil. If a clay soil, put a bed of concrete 6 inches in height and 6 inches wider each way than the thickness of the wall. On this place the brick footings; and in all cases, at 6 inches above the surface of the ground, place a layer of thick gas-tar mixed with coarse sand, or two courses of slate, over the horizontal surface of all the walls. The walls to be so constructed as to completely exclude wind and rain. The ground-floor should be raised at least 1 foot above the ordinary level of the ground, contributing most effectually to the dryness of the house. The height of rooms to be at least 7 ft. 6 in. from floor to ceiling. It is desirable that the front entrances should be at each end, keeping the two families separate. All the doors on the ground-floor to be not less than 6 ft. 6 in. high; those to the bedrooms 6 ft. 4 in. All the windows to be at least 4 feet high, and of good width, to slide. Casements on friction-rollers—bottom and top. The medical profession complain, and apparently with great justice, of the evils resulting from the draughts of sashes hung to work up and down, as when the lower sash is open the draught strikes the chest, and the top sash down, the draught strikes the head. As an established fact, many pulmonary complaints arise from sitting against windows thus open; and the oft-repeated inconvenience of opening the top sash, at times the most important one to open for good and efficient ventilation, is severely felt even in first-rate houses, and much more so in cottages; and a broken line to a hanging-sash causes much trouble to reinstate. This, in cottage building, is remedied by the adoption of sliding-casements. The slightest distance moved creates ventilation by the flow of air the whole height of sash. A projecting roof is of great importance; besides protecting the walls, it at all times gives a certain style to even a very humble dwelling. A porch adds effect to the building, and adds greatly to the interior warmth of the cottage. The floors to pantry and coal-cellar to be level with the footings to main walls. A brick bench should be placed in all pantries as a useful appendage. A sink should be placed in the scullery, through which slops of every description can pass through a trapped stoneware or iron sink (stoneware, as the most cleanly, preferred) to a trapped stoneware drain to the manure tank (a most indispensable requisite to the cultivation of a garden). Nothing will contribute so much to cleanliness in the house and at the door as for the wife to find that it is less trouble to deposit the slops in the sink than to carry them to the door. . . . . . .

Good drainage is indispensable; this may generally be obtained at a small cost. The common glazed earthenware pipes, 3 inches diameter, are sufficiently large to carry off the drainage from a cottage. All drains should be trapped with a syphon trap, thus preventing the escape of foul air, and the admission of vermin into the dwelling. The drain should empty into the manure tank adjoining the nécessaire, watering-place and pigstye. Cottages may be divided into several classes or sizes. One of the smallest size for a labourer and his wife, having no children, contains a living-room, bed-room, scullery, and pantry, with porch. Next size requires living-room, two bed-rooms, scullery, pantry, and porch. Third size, the same accommodation, with three bed-rooms. The rooms to each cottage are planned to a minimum size so as to be useful, at a cost to yield a good investment from a moderate rent."

The plans of cottages given in the book follow pretty well the indications in the above-mentioned extract, and the specimens appended show the style in which it is proposed to build them. It is perhaps proper to mention that earth-walls are proposed to be used, and that full directions are given in the book for building them; they are not understood in many parts of England, and consequently the account of them here given may be of value to persons who are disposed to make use of them, and who contemplate building to an extent that would render it worth while to introduce a new method into their district; for one of the great secrets of economy in cottage-building is as a rule to employ only those materials and methods of construction most common in the district where you build.

FOREIGN PUBLICATIONS.

Two works likely to be of interest to English readers are before us, though it is not now intended to give a detailed analysis of their contents in either instance. The first—entitled '*Cathédral de Bayeux: reprise en sous-œuvre de la tour centrale,*' (Paris. 1861. pp. 102, 25 plates,—contains an admirable account of the works lately undertaken and successfully carried out in repairing the central tower of Bayeux Cathedral. The recent fall of the tower and spire at Chichester has given to the works at Bayeux, and this published account of them, a great interest; for the circumstances of the two towers were very similar, and the causes of failure identical. This account is clearly written and copiously illustrated with engravings. Without attempting, at any rate in the present notice, to give anything approaching to a description of the works actually undertaken at Bayeux, we may in a few words from the concluding paragraphs of the work give the summary of the results obtained, which is thus simply and modestly laid by the authors before the public, after describing the removal of the last shores and stays.

"The work was now in fact ended; the downward motion of the tower, which, crushing its disconnected supports, threatened to carry after it the whole structure, had been first checked by shores, and subsequently arrested by the erection of trussed shores, for which it had been necessary to construct most extensive foundations in the ground; it had then become possible to reconstruct the piers in a very solid manner, and they supported the tower, which had not undergone any movement after the moment when it obtained its bearing on the trusses. These piers are not only capable of carrying the crowning feature (the spire), which will at a future day be added, but they also present four masses in the centre of the building strong enough to withstand the thrusts of the surrounding portions, and they afford, in place of a cause of ruin, a support to the whole remainder of the cathedral."

This volume very lucidly details the steps here summed up, and gives the results of experiments made on the strength of the materials employed during the progress of the works. The plates are clear, and in sufficient numbers to enable a reader to follow the various operations very easily, and the representations of the plan of the old pier, and of the cracks that had occured in those piers, are all the more interesting to an English reader because they are all but fac-similes of the same portions at Chichester.

Had works of this nature been undertaken in time at our English cathedral it is very probable that we should not have had to deplore the loss of one of the great ornaments of our country, and that—heavy as the expense would have been—they would have cost less than the proposed renovation of the tower and spire. The Bayeux works appear from the volume before us to have involved a total outlay of 855,000 francs, or about £34,200. It is hard to say whether the same works would or would not have cost more at Chichester—in all probability they would have been more costly, for the very lofty and ponderous spire would have required even more care in the treatment of its supports than was needed for those under the comparatively low lantern that crowns the crossing at Bayeux. Still, cost what it would, to retain the old spire would have been a great triumph; and to all who wish to prepare for meeting such an emergency as the failure of a tower with success, we can recommend this volume as of much practical value.

'*Des Concours pour les Monuments Publics dans le passé, le present, et l'avenir,*' by M. César Daly. This pamphlet on competitions will be more appropriately noticed in our series of articles on that subject, and a reference to it will be found at p. 209 *ante.*

Some further numbers of '*Nouvelles Annales de la Construction*' are before us, and fully keep up the excellent character which this work has acquired for variety of information on well selected subjects. In the number for June there is an excellent paper, though perhaps open to the objection that it is rather too elementary in its character, on the water supply of towns; followed by an account in detail of the system employed at Créteil, near Paris, with illustrations of the machinery. From the first part of this article we extract some interesting matter, premising that the measures are given in French litres—a litre being equal to 61·028 cubic inches, or about ·220 of a gallon; the amounts will therefore be slightly in excess of the truth if each litre be taken to represent one quart—but in an approximative calculation of this nature the error would not be large enough to be of serious importance.

"According to exact experiments a man consumes a daily mean quantity, for beverage and in his food, of 2 litres of water, and for external purposes of 18 litres. For a family composed of five members a mean consumption of 40 litres per diem is allowed. At Paris, the consumption is reckoned at

Per person daily	20 litres.
Per horse „	75 „
Per 2-wheeled carriage, daily	40 „
Per 4-wheeled carriage, daily	75 „
Per horse-power for high-pressure engine, hourly	200 „
Per horse-power for medium-pressure engine, hourly	400 „
Per horse-power for low-pressure engine, hourly	800 „
Per square metre of garden, yearly	500 „
Ditto, daily	2 „
Per bath, daily	300 „
For flushing gutters, per cock	5000 to 6000 „
For watering roads, per square metre	1 „

With these data, knowing the number of inhabitants, horses, &c., and of square metres to be watered or maintained, it is possible to calculate approximately the quantity of water it is necessary to raise from a stream, or draw from a spring; while the general lay of the town will give the positions of the different apparatus necessary for its distribution.

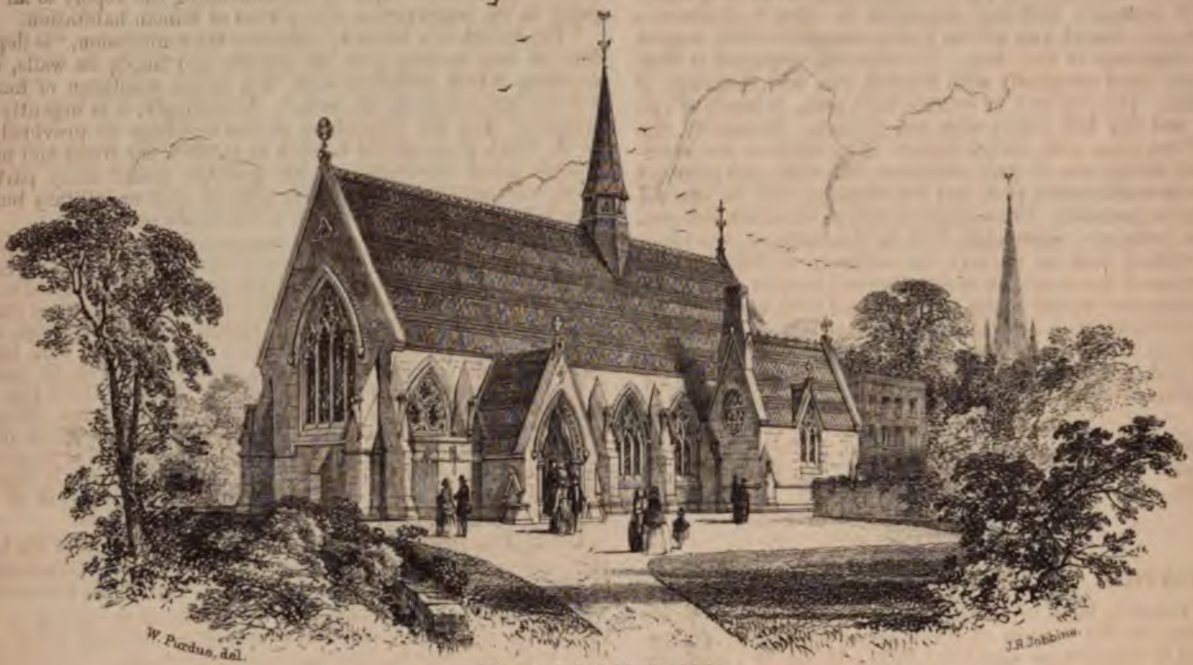
Table of the Quantity of Water distributed daily in certain Cities per Inhabitant.

Name of city.	Quantity. litres.	Name of city.	Quantity. litres.
Paris	60	Bordeaux	170
(it is possible to give)	120	Cette	106
Dôle	15 to 20	Lyons	85
Metz	20 „ 25	Nantes	60
Saint-Etienne	20 „ 25	London	112
Angoulême	35 „ 40	Glasgow	113
Sous-le-Saulnier ...	35 „ 40	Geneva	74
Gray	40 „ 45	Edinburgh	50
Havre	40 „ 45	Manchester	84
Clermont	50 „ 55	Genoa	120
Montpellier	50 „ 60	Philadelphia	70
Vienne (Isère)	60 „ 65	New York	568
Toulouse	62 „ 78	Richmond	180
Grenoble	60 „ 65	Brussels	80
Narbonne	80 „ 85	Munich	80
Carcassonne	300 „ 400	Rio Janeiro	9
Dijon	198 „ 678	Constantinople	20
Besançon	246	Ancient Rome	1084
Marseilles	470	Modern Rome	1105

◆

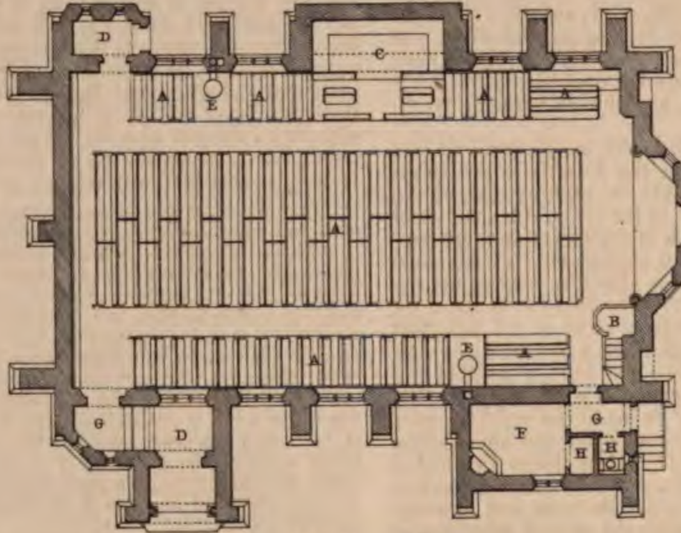
New System of Arranging Chimneys.—M. De Sanges, an architect, and M. Masson, have addressed to the French Academy of Sciences a paper regarding their system of arranging chimneys. It consists in uniting all the flues in one place, so that the smoke passes into a single chamber or receiver near the roof of the house, and from which the smoke escapes by an opening at the top of the chamber, in its centre. The system has been tried with satisfactory results. Eight flues opening into a single chamber, and used singly, or two, three, or more at a time, and with wood, coal, and coke, have been used for eighteen months, and the draught has been very regular under all circumstances.

The Association for the Prevention of Steam Boiler Explosions.—Mr. L. E. Fletcher, chief engineer, in his last monthly report, after alluding to a case where a tubular boiler had been materially injured by incrustation, states: "I am so constantly meeting with cases of this sort, where, from the neglect of the simple precaution of blowing out, a good deal of property is sacrificed, that—even at the risk of repetition—I cannot forbear calling the attention of members to it. I am constantly asked what should be done to remove incrustation which should never have been allowed to form; and beg to recommend, as the most simple means for its prevention, regular blowing out from the surface when the water is in ebullition, and from the bottom when it is at rest. I find the blow-out apparatus in many boilers very inconvenient, if not entirely unfit for use, some of the taps being so made that they cannot be opened—or, if opened, cannot be closed; others being rammed full of horse-dung till quite choked, to prevent leakage; while many have no waste-pipes, so that the boilers can only be blown out when the pressure is low, for the fear of scalding the men, and thus the practice is too frequently confined to the week's end. I may add, that perhaps as little trouble is experienced with a tap made with a close bottom, entirely of brass, and fitted with a gland, as with any other arrangement."


W. Purdue, del.
J.R.Jobbins.

J.Johnson, Archt 9 John St Adelphi.

New Chapel, Pilgrim Lane, Hampstead.



GROUND PLAN.

NEW CHAPEL, HAMPSTEAD, MIDDLESEX.

(*With an Engraving.*)

THE accompanying illustration gives a perspective view and plan of a very simple and elegant chapel now erecting in Pilgrim's-lane, Hampstead, a short distance from the Heath. The style of architecture is Gothic, of the Early Decorated period. This structure will architecturally be a great acquisition to the neighbourhood. It possesses sufficient ornament to give a distinctive character as a chapel, and will be highly suggestive with respect to future buildings of this class. The material employed is Hassock stone, faced externally with Kentish rag, with dressings of Bath stone. The roof will be covered with slate, in bands of two colours, and the bell turret with oak shingle. Internally, the roof is of one span, with curved braces. The whole of the woodwork and fittings are of deal, varnished; the aisles and passages paved with Staffordshire tiles; and the warming will be effected by Gurney's apparatus. The entrance-porch on the south side conducts to a lobby at a right angle with it, this arrangement being adopted with a view to prevent the entrance of draughts—so often a source of inconvenience in churches and chapels. Accommodation is provided for 450 adults on the ground level, and provision is made for the addition of a gallery at a future time. The design was prepared by Mr. John Johnson, architect, of 9, John-street, Adelphi, and is being carried out, under his superintendence, by Messrs. Dove, Brothers, builders of Islington.

References to Ground Plan.

A, A, Sittings.
B, Pulpit.
C, Organ.
D, D, Porches.
E, E, Stoves.
F, Vestry.
G, G, Lobbies.
H, H, Closets.

VENTILATION OF DWELLINGS AND HOSPITALS.

MANY valuable facts on subjects of practical importance are to be found in the reports of commissions deputed by government, and of committees appointed by the House of Commons, to investigate and report upon such subjects. Very recently, the report of a commission appointed to inspect barracks and military hospitals has been printed, and as it is conspicuous for the excellence of the opinions expressed, and the suggestions made on the subject of ventilation, we propose to give some account of that part at least of this report, connecting with it some notice of an earlier report presented to the General Board of Health by a commission appointed to inquire into the warming and ventilation of dwellings. The instructions to the Commission on Warming and Ventilating Dwelling-houses were given in May, 1856. The report is signed by Wm. Fairbairn, F.R.S., James Glaisher, F.R.S., and Charles Wheatstone, F.R.S. The instructions to the Barrack Commission were given about a year and a half later—viz. in October, 1857, and after the publication of the previous report; but so long and laborious was the task confided to the commission, that interim reports have been from time to time sent in, and the complete one was not issued until April last; it is signed by John Sutherland, W. H. Burrell, and Douglas Galton.

The circumstance which provoked the appointment of this commission was the presentation of the Report of the Royal Commission appointed to inquire into the sanitary state of the army. That report had shown that in the army, when stationed on home service, there was an excess of deaths per annum above the average rate of deaths prevalent among males of the same ages in England and Wales, to an alarming extent; for the deaths among the soldiery were shown to be 17·5 in the 1000 per annum, while those among civilians stood at 9·2 per 1000 per annum. So remarkable and significant a fact pointed to the condition of the dwellings of soldiers, and to their mode of life, as requiring alteration; and the commission whose report is now before us was appointed to examine in detail the buildings used as barracks and hospitals, and to report upon and superintend improvements possible and requisite. These duties required a vast amount of attention to details, and rendered necessary a number of distinct reports on separate barracks and military hospitals. The present document gives the general principles as well of future constructions as of improvements in existing buildings, and embraces both theoretical and practical generalisation; and the most prominent topic, whether dwellings for the healthy soldier, (*i.e.* barracks) or hospitals for him when sick, are under consideration, is the one which forms the subject of this paper.

The portions referring to military hospitals will be almost as valuable to those engaged in the study of civil hospitals as to persons especially engaged on army works; and so large a part of the observations relative to barrack-rooms is so perfectly applicable to other rooms where many human beings live or sleep, that we make no scruple in recommending the report to all engaged in the construction of any kind of human habitation.

"The health of a barrack," observes the commission, "is dependent on free moving pure air outside and inside its walls, and anything which interferes with this prime condition of health will act injuriously on the men." Accordingly, it is urgently represented that the disposition of the buildings as provided for on the block plan, should be such as to allow the freest and most uninterrupted circulation of air possible round every part of them,—an essential requirement, alike of civil or military buildings, but one to which attention is but rarely given.

> "The errors in plan most frequently committed are the following:—Want of simplicity in the general arrangement of the blocks; buildings so placed as to interfere with the ventilation of each other; buildings erected round closed courts, or with deep, closed angles; barrack-room buildings placed too close to the boundary walls; with latrines, urinals, dung heaps, ash-pits, &c. placed in a narrow space between the barrack and wall; buildings in which the men are concentrated in one or two large blocks, instead of the barracks being spread over the ground. These errors in plan include hospital as well as barrack rooms, and their general effect as regards health is to obstruct that free movement of the external atmosphere over all the surface of the buildings which is essential to the preservation of purity of the air within the rooms. Free access of light is prevented, and the air, already stagnated by the arrangement of the buildings, is liable to be rendered more impure by nuisances."

Descending from general arrangement to the details of the barrack-rooms, the commission found that the evil of overcrowding, along with utterly insufficient ventilation, was all but universal.

> "No doubt this unsatisfactory state of regulation as to cubic space has arisen from the circumstance that those persons intrusted with giving effect to the regulation have not appreciated the influence of overcrowding on the soldier's health. They have not been aware that if above a certain number of men are placed in a given cubic space, the lives of some of these men, and the health of others, are certain to be sacrificed. They have not considered that to this overcrowding and its concomitant want of ventilation a large part of the excessive army mortality is due."

The amount of space which it is proposed to allot to each soldier occupying a barrackroom is 600 cubic feet. The value of this space is not that it contains air enough to supply his respiration for a great length of time—for it would not remain fresh for an hour—but only that it allows of the contained air being changed constantly, and yet gradually, without violent and injurious currents.

The opinions of competent authorities have varied very much as to the *amount* of air required to be removed in a given time, and replaced with fresh, for each occupant of a room. In both the documents before us the amount named is substantially the same—viz. from 15 to 20 cubic feet per minute. The barrack committee, adopting the largest of these amounts, considered that they were bound to provide means for introducing and removing 1200 feet of cubic air per man per hour—or, in other words, for renewing the air in the rooms once every half-hour. How to do this efficiently was not at once obvious.

> "The following is the problem requiring to be solved in ventilating a barrack.—In a building consisting of a number of rooms, generally entered from common passages or staircases, sometimes directly from the outer air, and each having an open fireplace—which it is essential in every instance to retain—how to supply, at all seasons and temperatures, and by day and night, each room by itself, and independently of every other room, with a sufficiency of air to keep the room healthy, and at the same time to prevent the temperature from falling below what is required for the comfort of the men;—to do this with the least possible interference with the structure of the rooms, on a plan not easily deranged, and at a minimum cost? The terms of this problem show at once the difficulties in the way of ventilating barracks. None of the methods we have seen in use afford anything like a solution of it, and we have had to consider the whole problem anew. We have endeavoured to solve it, and believe we have succeeded in doing so to an extent sufficient for all practical purposes."

Various inventions and systems were reviewed by the commission before coming to the conclusion expressed in the above extract; they are thus classed—

> "The plans submitted to us were as follow:—1. Method of propelling

air into barrack-rooms by fan-wheels and screws driven by steam, or by other mechanical means. 2. Method for extracting air from barrack-rooms by the draft of a heated flue, or by mechanical contrivances. 3. Methods of removing the air by shafts or openings, variously planned and arranged. All, or nearly all of the plans in the first and second classes provide for warming the air admitted, and dispense with the open fire-place."

These methods are succintly and fairly reviewed, and Arnott's and Sheringham's ventilators are described as having been in some cases successfully introduced into individual rooms. As there is nothing more often desirable than a good and simple method of ventilating existing rooms in dwelling-houses, we may draw special attention to the combination here recommended, of an Arnott valve, which is an outlet, with a Sheringham, or inlet valve. From experience we can speak well of the satisfactory action of the two in conjunction, and also can corroborate the observation made here more than once, that it is *essential* to the successful action of an Arnott valve that the throat of the chimney should be narrowed below it. If this be not done, the valve will at times admit smoke into the room.

Watson's, Mackennel's, and Muir's ventilators, and several elaborate systems for the ventilation of large buildings, are discussed, their merits fairly admitted, and the reasons which forbade their general introduction into barracks clearly stated. The method which was at last adopted was to extract a portion of the vitiated air by shafts carried up vertically, the movement of air in them being occasioned by the greater lightness of the escaping air than that of the outside atmosphere; the chimney-flue was relied upon for removing the remaining part of the air required to be extracted. The fresh air to replace that extracted was introduced partly by direct inlets, and partly by inlets communicating with a chamber behind the fire; so that in winter a portion at least of the fresh air shall be warmed when it enters the room.

(To be continued.)

THE EMBANKMENT OF THE THAMES.

Report of the Commissioners.

We the undersigned members of your Majesty's commission—appointed to examine into plans for embanking the river Thames within the metropolis, so as to "provide with the greatest efficiency and economy for the relief of the most crowded streets by the establishment of a new and spacious thoroughfare, for the improvement of the navigation of the river, and which will afford an opportunity of making the low-level sewer without disturbing the Strand or Fleet-street, and also to report upon the cost and means of carrying the same into execution"—now humbly submit to your Majesty the conclusions at which we have arrived, and the recommendations we have agreed to offer.

2. The nature of the inquiry entrusted to us was made known to the public by advertisement in the newspapers, and more than fifty designs were presented for our consideration; and the authors and other persons interested have had the opportunity of publicly explaining and illustrating their respective views upon the subject.

3. The main features of the majority of the plans are an embanked roadway on the north side of the river and the formation of docks with the view to retain all the existing wharves; in others, railways in addition to the roadway and docks have been proposed; whilst in a few a solid embankment and roadway, without either docks or railways, have been suggested. Amongst these latter is a plan by Mr. Shields, some of whose suggestions appear to us to afford in a greater degree than any of the other designs the basis upon which an efficient and economical scheme may be founded. We desire however to express our high appreciation of the great engineering skill and ability that has been displayed in many of those designs which contemplated the construction of docks and railways.

4. The wharf property between Westminster-bridge and the Temple-gardens is for the most part devoted to the coal trade. We find that great facilities are now afforded for the distribution of coal by the new system of unshipping in the docks into railway waggons, and by various depôts on the railways in and near the metropolis. We are of opinion that public convenience no longer necessitates the continuance either of the coal or any other trade in this immediate locality. We therefore think that it would not be expedient to construct and maintain docks for the sake of preserving the existing wharves between the points we have mentioned; whilst their removal will greatly simplify the formation of the embankment, and add to the beauty of the river. The wharf property however between the Temple-gardens and Blackfriars-bridge cannot, in our opinion, be so treated; and that eastward of Blackfriars-bridge is so important in a commercial point of view, that we do not recommend any interference with it.

5. Having regard to these and other considerations, we are of opinion that we shall best fulfil your Majesty's instructions, and provide for the requirements of the public, by establishing a spacious thoroughfare between Westminster-bridge and Blackfriars-bridge, by means of an embankment and roadway; and that the new thoroughfare thus created should be continued on eastward from Blackfriars-bridge by a new street, according to the line formerly laid down by Mr. Bunning, the City's architect, from the west end of Earl-street, across Cannon-street, to the Mansion House. Without such a street no relief whatever would be given to the crowded thoroughfares of Ludgate-hill, St. Paul's-churchyard, and Cheapside.

6. The line of embankment at Westminster would coincide with the terrace of the Houses of Parliament, and from thence to Blackfriars-bridge would nearly follow the line laid down for the Corporation of the City of London in 1841 by Mr. Walker, Capt. Bullock, Mr. Saunders, and Mr. Leach. The general level of the embankment and road would be 4 feet above Trinity high-water. The road would commence at Westminster by an easy descent opposite the Clock Tower, and be continued on, 100 feet in width, to the eastern boundary of the Temple-gardens; from this point the road would be reduced to 70 feet in width, and carried on a viaduct supported by piers of masonry, rising to the level of Blackfriars-bridge, so constructed as to leave a breadth of water for the convenience of the City Gasworks and the adjoining wharves, of about 70 or 80 feet. The spaces between the piers under the ascending road would be left available for barges to lie, and afford easy access to the water between this structure and the wharves.

7. From Westminster-bridge to the eastern boundary of the Temple-gardens, the embankment—sustained by a river-wall—would be solid in its whole breadth; which breadth opposite Richmond-terrace would be 220 feet from the existing river-wall. At Hungerford it would be 320 feet from the existing wharf; at Somerset House about 120 feet; and at the Temple about 220 feet.

8. With respect to the appropriation of the reclaimed land, we would recommend that so much of it as shall be in front of the Crown property—which will be about 120 feet in width in its narrowest part—should be laid out in ornamental gardens for the accommodation of the occupiers of the houses, and that the portion in front of the Temple-gardens—also about 120 feet wide—be placed at the disposal of the society, to be dealt with in a similar manner. The other portions of the reclaimed land may either be kept open for the health and recreation of the public, or be applied to building purposes.

9. We propose that communications should be made with the intended roadway from Whitehall, opposite the Horse Guards, and also from some of the streets in the Strand; and that a new street should be formed, passing through the Savoy to Wellington-street. The frontages on these streets would offer eligible sites for building, as would also the inner frontage of the new road, if it should hereafter be thought fit so to utilise the ground. We however feel it our duty to recommend, that while economy and utility in laying out and disposing of the ground should be kept in view, endeavours should be made to invest this new and conspicuous work with some elements of interest and beauty.

10. For the improvement of the navigation we recommend that the existing shoals between Waterloo and Westminster bridges should be removed, due regard being had to the foundations of the former. Also that an uniform low-water channel of 6 feet in depth at ordinary spring-tides, and 500 feet in width from the embankment-wall, be secured, and thus the stream be more equalised in velocity. If at any future time any effect should be produced on the river from the diminution of its capacity for tidal water by reason of the embankment, arrangements may be made higher up the river by dredging, or by a tidal reservoir, to compensate for the loss. The consideration however of this matter would naturally devolve on the conservators of the river Thames.

11. The embankment and street we have proposed will afford an opportunity of making the low-level sewer without disturbing the Strand or Fleet-street, and at the same time facilitate the construction of the sewer eastward of the embankment.

12. We are not prepared to recommend the construction of an embankment on the Surrey shore at present, but if hereafter it should be thought desirable or necessary to embank any portion of it, the scheme we have proposed for the Middlesex side will not in any way interfere with it.

13. With regard to that part of our instructions in which we are commanded by your Majesty to "report on the costs and means of carrying the same into execution," we beg to report that we estimate the cost of the land, making compensations, constructing the embankment and roadways, and also acquiring the property in the City for, and forming the new street to, the Mansion House, at £1,500,000. This amount however would be reduced should it be thought right to dispose of any of the reclaimed land on the bank of the river for building purposes.

14. Parliament having appropriated the coal dues to provide for the outlay necessary for this great work, it only remains for us to express our opinion as to the "means of carrying the same into execution."

15. Looking at the magnitude of the work, the important and varied interests, both public and private, which will be effected, and the urgent necessity for its early completion, we are of opinion that the control and management of the undertaking should be entrusted to a special commission, appointed by your Majesty, in order to insure the speedy and economical attainment of an object so much needed by the public, and affording so favourable an opportunity for the improvement of the river and adornment of the metropolis.

William Cubitt.
Joshua Jebb.
Douglas Galton.
Edwd. Burstal.
Henry A. Hunt.
John Robinson M'Clean.

22nd July, 1861.

THE COMPETITION DESIGNS FOR THE HOUSES OF PARLIAMENT, SYDNEY.

The designs for the New Houses of Parliament and Government buildings, proposed to be erected at the entrance to the Domain, in Macquarie-street, have been publicly exhibited in the new reading-room of the School of Arts, Sydney.

The following gentlemen have been appointed commissioners to decide upon the award:—The Colonial Secretary, the Minister for Lands, the Minister for Works, the President of the Legislative Council, the Speaker of the Legislative Assembly, Sir William Macarthur, Mr. E. Deas Thomson, Sir Charles Nicholson, Captain Ward, and Mr. Whitton. The functions of the commissioners will be confined to making the awards, no promise being made that either of the successful designs will be carried out. Even should a design be selected, the question of cost threatens to present a serious obstacle to its execution. It is stated that to erect any of the proposed buildings would involve an outlay of above £200,000. One of the designs—and that by no means the most elaborate—is estimated by its author to cost in execution £500,000 at English prices, and the cost of carrying out one of the more handsome designs has been computed at a million and a quarter.

The number of designs received is twenty or twenty-one, including two separate designs accompanying one set of plans. Of these, eleven were from England, and the remaining nine from Sydney and the adjacent colonies. There is nothing in their appearance to distinguish the colonial from the European designs. Only the names of three or four of the competitors appear to be known in Sydney; and it has been confidently stated that more than one of the designs which are most admired are colonial productions.

Considering the means that have been taken to invite extensive competition, the expectations of many persons with regard to both the number and the character of the plans have been disappointed. The principal reason offered for the fewness of the competitors was, that English and European architects were not disposed to compete where the successful competitor would not have the carrying out of the work. The supposition that a large number of English architects would send in plans operated to deter colonial architects from competing, thinking, no doubt, that they would stand little chance of success. Some of these regret that they did not tender, believing that they could have produced designs, if not of greater architectural merit, at all events better adapted to the situation and to the purpose than many of those exhibited.

The subjoined notes upon a few of the designs are condensed from the *Sydney Morning Herald*:—

"Palladio."—The stipulations as to the elevations being in simple outline is violated in this design, but only to the extent of colouring with sepia one of the perspective drawings. Without that aid it would be recognised as possessing very great merit. The design is Italian, and essentially palatial in its character. There is a bold, deep, rusticated basement, above which a row of Corinthian columns support a massive entablature relieved by a rich balustrade. In the upper portion of the elevation rustication is introduced with very good effect. Several towers are introduced, large but well proportioned. The shape of the building is oblong, the two chambers extending eastward and westward from an open court in the centre, the Government Offices ranging round the building. There are, altogether, seven courts, each of which is ornamented by a fountain.

"Hora e Sempre."—There are two designs under this motto, the one Classical and the other Gothic. The Classic design is extremely massive and imposing. Ranges of stately Corinthian columns, with massive entablature and pediment, approached by a broad flight of steps, and crowned with a shapely octagonal tower, together with the harmony of the various members, constitute an ideal of palatial magnificence. There are a few defects in the plan, such as the absence of colonnades, which might be remedied if the design were adopted. In the plan, the parliamentary offices occupy nearly half the block, the chambers extending parallel east and west. The harbour front is devoted to the Public Offices.

The Gothic design is also exceedingly handsome. It is, indeed, so beautiful a specimen of that style as entirely to propitiate the favour of those who are opposed to the application of the Gothic to such purposes. Over the grand entrance there is a massive tower, well shaped and richly finished. The elevations of both of these designs are so arranged that the one set of plans will do for either of them.

"Dan York."—The architecture adopted in this design is a very close copy of the Louvre, in Paris; indeed, there are reasons for believing that the drawings have come from France. In the elevation, Corinthian columns alternate with windows with circular pediments, which, in combination with the artistic adjustment of the other parts, produce a very rich effect. Some pavilion towers are introduced. One of the towers, which is ascended by steps outside, affords a spacious promenade. The figure of the block is nearly square; it is divided into nine almost equal squares. Each of these is made use of for a court, excepting the centre divisions on the east and on the west sides, the former of which is devoted to the Assembly Chamber, and the latter to the Council Chamber. Both of the chambers are simicircular in shape.

"I bide."—The architect of this design has violated one of the conditions of the competition, which was, that none of the elevations should be coloured. A perspective drawing of the proposed building is very cleverly coloured, giving artistic effect to an extremely beautiful design. Great admiration is bestowed upon this picture, which is not to any great extent to be attributed to the painting, as an uncoloured view of the same perspective, hung up alongside, is almost equally attractive. The design is Gothic, in some of its parts resembling the Doge's palace at Venice. Several lofty Moorish towers, including a campanile, with richly decorated spires, are introduced. The effect of light and shade is most artistically studied in the elevation, the bold and numerous projections throwing pleasing shadows across the other portions of the structure. The plan of the building is nearly square, except that on the east side there are two wings. The Legislative Chambers are at the eastern end of the building; the interiors of these are equally elaborate with the exterior. There are altogether thirteen courts, but these are of very small size, and apparently insufficient for the thorough ventilation of the building. Convenient colonnades extend between the towers.

"Res non Verba."—This is a very striking Classical design. There is a general resemblance in the design to the new Town Hall at Leeds. Handsome Corinthian columns surround the building, with a pediment and spacious peristyle at the east and at the west elevations in the centre, between which rises an enormous tower, of tasteful design. The columns form quite a forest round the building, being in the peristyles five deep. The tower stands in the centre of a spacious court, and is connected with the floor of the building by a gallery. Midway between the tower and the pediment at either end are corresponding domes, beneath which are circular halls, that towards the eastern side of the building being the Parliament Hall, and that to the western side the Official Hall. The former communicates with the Council Chamber on the right, and the Assembly on the left. The peristyles are ascended by broad flights of steps. The columns round the building form spacious colonnades.

"Spes."—This design is in the Italian style, and arrests attention by its boldness and breadth of effect. The buildings are divided by four main arteries of communication, two running east and west, and two north and south; the various departments being connected by continuous colonnading.

"Fide et Virtute."—The style of this design is the Continental Gothic. There is a lofty dome and a clock-tower, and the projecting portions of the elevation are set off with overhanging and pinnacled turrets.

"Sic fortis Etruria crevit."—This design is in the Pointed style, evidently well considered; but though tasteful, it cannot be called handsome.

"Pynx."—This is a design in the Italian style. There is a lofty tower, consisting of six rows of columns.

"England and New South Wales."—These drawings are in the French Italian style. The absence of towers gives the elevation a heavy, flat appearance; and, a further defect, there is a deficiency of colonnades.

"God's Providence is mine inheritance."—This is a Gothic design, exhibiting long ranges of collegiate looking buildings, not altogether destitute of beauty, but completely killed by cruel maypole towers, the height of which is in painful contrast with the lowness of the buildings. There is nothing very striking in the plan to redeem the above defect. The Assembly Chamber is to be about 100 feet by 60 feet, and somewhat similar in form to the English House of Commons: the galleries, instead of projecting, range behind columns which assist to support the roof. The Council Chamber is of the same size, but has smaller accommodation for members.

"CH. C. H. S."—This is a Classic design of considerable vigour and beauty. In the centre is a handsome dome, to be of solid stone, with perforations for light, relieved at the base by equestrian statues. There is a great deal of finish in the design; but it has nevertheless an aspect of foreignness and singularity. The architect has apparently a great dislike of rectangular figures. The grand entrance is semicircular, and allows for a carriage-drive through it. The plans provide for the Parliamentary Offices, but make no provision whatever for the Government Offices.

"Follower of Wren."—This motto is appended to an adaptation of the architecture of St. Paul's Cathedral. The *ensemble* has much symmetrical beauty.

"Akropolis."—This is a design after the model of Buckingham Palace; but it is more like the pictures of ancient Grecian temples than any modern structures. The plan is extremely simple, and in theory, at least, appropriate. The Government Departments are allotted to a range of buildings almost inclosing a quadrangle, in the centre of which as the supreme tribunal—the source of all executive power and authority—is a temple for the legislature. The quadrangle opens on the east side, to afford a good view of the eastern façade of the centre building.

"Omega."—This is a Classic design, but the working out of the details is original, and a curious effect is produced. The towers are extremely plain, and add little beauty to the elevation. On the ground plan there are, on the south side, three long parallel courts, separating portions of the building that are assigned either to a department or a sub-department, but built over by the upper story.

"Si je puis."—This is rather a pretentious Classic design, but the general effect is not pleasing. A number of columns are introduced merely for effect, and there is a palpable want of solidity and massiveness in the composition.

"Mars."—A very curious design, which may be called a Gothic extravaganza."

"Utility."—Gothic.

"Αθηνη."—This is a Classic design. The drawings are rough and unfinished.

M. DALY'S PAMPHLET ON ARCHITECTURAL COMPETITIONS.

We propose to supplement the observations on competitions which have appeared in this Journal,* by now giving a short account of the views embodied by M. César Daly in his pamphlet mentioned in our last number, and entitled '*Des Concours pour les Monuments Publics.*' M. César Daly is entitled to be heard with respect, as the editor of one of the oldest professional journals in France, and as being himself an architect of standing. His pamphlet, which has excited a good deal of attention, is addressed rather to the general public than to any class of readers, and is limited in its application to public works proposed to be undertaken by government; but in this country it loses part of the point which it possesses in France, where a very considerable number of architects hold government appointments, and consequently expect, and not without reason, that government works shall be placed in their hands. M. Daly, who himself holds the post of one of the government architects, is not hindered by any difficulties which his official position might seem to throw in the way of his thinking freely, and giving unconstrained expression to his opinions. He advocates—and that with uncompromising decision—the adoption of the system of competition for public or government works. M. Daly urges that for these works a public, open competition will be of the greatest advantage to art, artists, and the public; and refers to a few—very few—instances of such competitions in France as having been occasions of marked interest. He boldly declares himself in favour of the most unconditional and extended application of the system, and manfully advocates the claim of the artist whose design is successful, to employment as architect of the building. The advantages claimed for the plan of public competition are that the best and best known architects, as well as others, would compete for public works of importance; that by honourable rivalry they would be sure to be stirred up to exertions greater than they would make under any other system; and that at the same time an opportunity would be afforded to any remarkable genius unknown to fame, or unconnected with the official staff, to signalise himself, and win fame and fortune by his own merits.

The experience of our own country, with regard to the Foreign and War Office competitions, shows the soundness of the presumption that our greatest public men would enter the lists in cases where works of great importance are concerned. On that occasion we saw most of the best known of our architects, including Barry himself, engaged in one or another portion of the contest, and we also witnessed the triumph over these of men comparatively little known, and whose success could not have been anticipated. The issue of the competition was in this respect most honourable to the judges. The fact that neither M. Crepinet, Mr. Garling, or Messrs. Coe and Hofland is in any way employed on the work now is not equally creditable to the government. M. Daly prepares, however, for the case—which actually did happen among ourselves—of the government being unwilling to commit the work to the successful competitor, by suggesting that if he be inexperienced, a coadjutor might be added to him; and if it be really found impossible to commit the work to his hands, then an increased premium should be paid as compensation.

The greater difficulty, so much felt in our private or municipal competitions, is the selection of the tribunal. In the largest recent *public* competitions in England, those for barracks, and those for the government offices, the tribunal has commanded general confidence and respect, and its decisions have on the whole received public approval. M. Daly proposes a jury, of a rather unmanageable extent—namely, thirteen members, and indicates the sources from which he would propose to draw them; to enumerate these would not interest English readers, suffice it to state that he proposes as a means of securing that all shades of opinion should be represented, a combination of professional and amateur, official and non-official members, and that four members should be selected by the competitors themselves. This proposal in the exact form here made is only applicable to France, but perhaps something analagous to it might be with advantage devised for England. The further proposal that a written report should be furnished by the judges, and published, is most desirable; and it would be, if practicable, a great advantage for such a report to be in the hands of the public while designs are open to inspection.

---

* See *ante* pages 91, 167, 208.

Among other arguments urged in favour of an habitual resort to competition for public buildings is the rather important one, that the progress of architecture, and its position at certain periods, could be better exhibited by great public competitions than by any other method; and that they would contribute to promote that progress. It is even asserted that "we require competitions as an indispensable method of periodically and completely ascertaining the condition and the changes of architectural ideas." This is a desideratum no less important to ourselves than to the public and the profession in France, and one which the professional press and the Architectural Exhibition supply partially, but by no means completely, in this country. In many respects it is impossible to draw a complete parallel between our requirements and those of France; notwithstanding which however, we feel that M. Daly has brought forward some considerations that ought in England as well as in France to have weight in favour of government competitions for public works of importance, where a thoroughly competent and honourable tribunal can be found. It is the difficulty of procuring this tribunal which we have pointed out as one of the greatest evils attending competitions of an ordinary scale. We fear however that the behaviour of our government, *after* the adjudication of the prizes offered for designs for the government offices had been made, will be found—should another great competition be ever called for—to have dealt a great blow in England to the efficiency of that part of the whole competition system which naturally is most likely to be efficient. A fair rivalry is no doubt beneficial to the public, and advantageous to artists, but to be healthy and useful it must take place under fair conditions, and with an undoubted security as to the ultimate result.

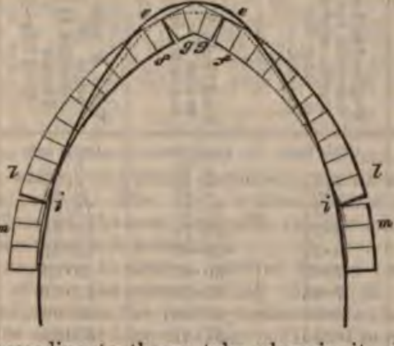
THE STATICS OF BRIDGES.

(Continued from page 166.)

We have now pursued the idea of the dry arch of incompressible voussoirs to its logical consequence, namely, that the Line of Pressure must meet the outer and the inner surfaces (known as extrados and intrados) before the thrust can be generated and equilibrium attained. We have also seen that when the Line of Pressure actually passes beyond the voussoirs there will be rupture, the conditions of equilibrium being no longer satisfied. It is therefore essential to the stability of the arch that the Line of Pressure touch both extrados and intrados; and also that it lie wholly within these limits.

To see by what kind of process the path of resultant pressure may be supposed to adjust itself, so as to satisfy these conditions, we will take the arch shown in Fig. 15, and examine the action that would according to theory take place in it. We are still assuming that the arch is incompressible.

Fig. 15.



The keystone being the point where the load naturally divides, the two semi-arches tend to turn downwards. In order for this tendency to become sensible, so as to create thrust against the abutments, the Line of Pressure (for reasons already given, p. 116, col. 1) must meet extrados at the keystone and intrados at springing. If the line of pressure so drawn lay entirely within the voussoirs, equilibrium would at once ensue. But in the case of the arch now under consideration, this Line of Pressure, on being drawn, is found to pass outside the voussoirs. It is shown by the full line, which meets extrados at the keystone and intrados at springing, but passes above extrados at *e*, and below intrados at *i*.

The joints at *e* will therefore tend to open, by the voussoirs turning on their upper edges. At the same time, the voussoirs between *e* and *i* have no tendency to turn, because the Line of Pressure lies within their margins. The tendency of the voussoirs at *e* to turn will therefore have the effect of bringing their edges *f* and *g* to bear hard against the voussoirs below them and against the keystone. This action cannot fail to lower the line of thrust both above and below *e*, for it is impossible for the resultant thrust to be at extrados so long as there is any pressure on the lower edges of the voussoirs.

In the same way the tendency of the joints at *i* to open has the effect of raising the Line of Thrust on either side of *i*, by throwing a pressure on the edges *l* and *m*. The Line of Thrust must therefore work itself upwards near the springing, and downwards near the crown. This adjustment can only stop when the Line of Thrust assumes the form of a Line of Pressure touching extrados near *e* and intrados near *i*, but nowhere passing outside the margins of the voussoirs; as indicated by the dotted line. We may thus take it to be invariably true, that the Line of Pressure in which the resultant forces would find their equilibrium in an arch built of dry and incompressible voussoirs is the one which, while it touches intrados towards the springing and extrados towards the crown, nowhere passes outside the arch. It consequently has the greatest total rise of all the lines of pressure that are contained within the limits of the voussoirs; and is therefore the one which gives the least horizontal thrust.

In the arch shown in Fig. 15, the points of contact of the Line of Pressure with extrados and intrados at *e* and *i* are the points where (according to the present hypothesis) rupture would first show itself if the arch failed. They may therefore be called the Points of Rupture; it being at the same time quite understood that the term means no more than what has just been stated, and does not imply actual failure. It is the settlement, or rather the moment of rotation, of the portion of the semi-arch between these points of rupture (*e* and *i*) that generates the thrust. When, as in the instance before us, there are *two* upper points of rupture (*e*, *e*), the portion of the crown which lies between them stands through the thrust impressed upon it by the action of the lower parts (*e i*) of either semi-arch, and is in effect one broad keystone. And the portions (if any) of the arch between the lower points of rupture (*i*, *i*) on either side and the springing stand also through the thrust impressed upon them by the upper portions (*e i*) of the arch, and might almost be regarded as forming integral parts of the abutments.

The fiction of an incompressible arch has thus far led us to a solution consistent in detail, and general and (it is hoped) intelligible in its application. Possibly not very widely at variance with what really takes place in a masonry arch; at least, not involving hazardous error in structures of this class. If the solution be one of an empirical kind, it can at all events claim the sanction of eminent mathematicians and the prescription of usage. It has hitherto been accepted as virtually correct by those who have undertaken to examine or to explain the subject. If at some future time, when we come to speak of iron arch ribs, we should take occasion to find the *true* Line of Pressure, it would be by a process (as yet not generally known) in which the line of the *neutral axis* is considered instead of those of extrados and intrados. But for the present we need not concern ourselves with this refinement, and may content ourselves with results which have hitherto been taken to be accurate enough for practical use. All our care may consequently be given to simplifying the *method;* and here there is yet something to be done.

The method divides itself into the delineation of the *form* of the Line of Pressure and the fixing upon the *position* of the Points of Rupture. Where these latter come just at the crown and springing, the whole matter is comparatively easy, the only thing needed being to draw a line following a certain law between two known points. But where—as in a semicircular, or a "basket-handled," or a pointed arch—the Points of Rupture assume intermediate positions, difficulties grow and multiply at a formidable rate. The form of the Line of Pressure depends upon the position of the Points of Rupture, while the position of these Points is equally dependent upon the form of the Line. Thus adjustment has to follow adjustment, as we take up alternately the one side of the problem and the other; the errors becoming less and less, until at length they cease to be of account. The determination of a question of this nature is not without its charms for the geometrician who, calling algebra to his aid, may be enabled successfully to cope with the difficulty. But an abstruse algebraic solution, great as may be its theoretic merit and value, is actually useless to the majority of practical men. They find themselves simply baffled and perplexed in the maze of curious symbols; what they seek is to be brought to the very threshold of the special answer for each special case, by some plain and ready rule—to be worked out at once, whether by a sum on the slate, or by a diagram on the drawing.

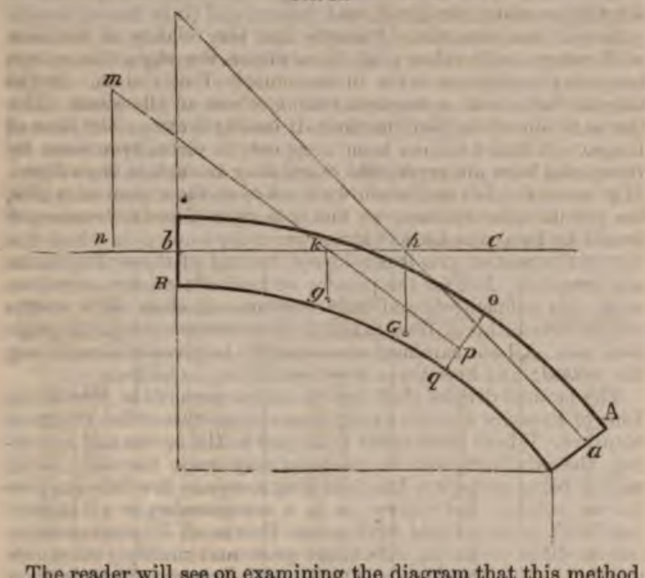
In the case of an arch of one radius there has indeed been given an arithmetical rule for approximating to the Points of Rupture. But this involves a tedious and complicated calculation, which has to be repeated, and again repeated, as often as may prove necessary, until a result is arrived at sufficiently near the truth. A comprehensive, simple, and easily applied method, for fixing at once on the Points of Rupture in any case that can possibly arise, has hitherto been lacking.

Much more has been done with regard to the other part of the question—the form of the Line of Pressure. Rules have been given that make its delineation a straightforward task as soon as it is taken for granted that it passes through a given point at the crown and another given point at the springing.

The method easiest to understand is the mechanical method, as it may be called. This will be found clearly explained and largely illustrated in an able and very interesting paper by Mr. W. H. Barlow (read at the Institution of Civil Engineers in 1847), which is given in vol. x. of this Journal, page 211. The entire paper, and also the discussion which ensued (given some pages further on in the same volume), will well repay perusal. But we will extract the rule given by Mr. Barlow for finding the points where the Line of Pressure intersects the successive joints between crown and springing. These points he determines by means of the positions of the respective centres of gravity of the semi-arch and of the upper portions successively remaining between the several joints and the crown, in the following manner:

"Let *a* and *b*, Fig. 16, be two points in the curve of equal horizontal thrust in the arch AB; required to find the point at which the curve intersects the joint *oq*. Let G be the centre of gravity of the half-arch AB, and *g* that of the portion *oq*B. Through *b* draw the horizontal line *cn*, and the vertical line *bl*; also through G and *g* draw the vertical lines G*h* and *gk*, intersecting *cn* in *h* and *k*; join *ah*, and produce it to *l*; from *k* set off *kn*, equal to *hb*, and through *n* draw the vertical line *nm*, making *nm* to *lb* as the weight of the portion *oq*B is to the weight of the half-arch AB; join *mk* and produce it until it intersects *oq*: *p*, the point of intersection, will be the point required."

Fig. 16.



The reader will see on examining the diagram that this method for fixing points in the "curve of equal horizontal thrust" (or, as we have preferred calling it, the "Line of Pressure") proceeds on the principle of the resolution of forces. To begin at the beginning, the necessary steps will be the following:—

1. Assume the points *a* at springing and *b* at crown, through which the Line of Pressure is presumed to pass.

2. Find the weight of the semi-arch AB, and fix the position of its centre of gravity G.

3. Find the weight of the portion *oq*B, and fix the position of its centre of gravity *g*.

4. Proceed, according to the method just given, and shown in the diagram, to ascertain the point *p*.

Here we observe that steps 3 and 4 must be repeated for every point that has to be determined. The finding of one centre of gravity affords no help towards finding the centre of gravity next wanted: and the process for arriving at each cannot fail to be tedious when we take into account the different specific weights of the stonework and the earth filled in behind it, to say nothing of any load on the roadway. Each repetition of step 4 involves a rule-of-three process, or something equivalent, in order to find the length of the line *mn* from that of *lb*.

While therefore this process is correct in principle, and shows much simplicity and beauty in its conception, it will entail no small sum of labour when it comes to be applied, if we include the preliminary steps which form an essential part of it. This is supposing that the points *a* and *b* have been *correctly assumed.* If, as in an elliptic arch, the points of rupture have to be determined by trial, although the centres of gravity will of course not have to be found a second time, the course of geometrical construction will have to be gone through all over again, once or oftener, until a satisfactory result is hit upon. In such a case, the task of thus arriving at the Line of Pressure would become really formidable.

A method not at first so readily understood as the preceding, and requiring for its explanation a differential equation, is the algebraical process, founded upon the relations between the differential coefficient of the Line of Pressure at any point, and the total weight from that point to the crown of the arch. This process is however less tedious in application, if not really simpler, than the mechanical method just illustrated, since it quite dispenses with the finding of centres of gravity. The determination of the Line of Pressure of a fly-bridge of 52 feet span, on the South Wales Railway, formerly communicated to the writer by the courtesy of the gentleman who achieved it, may be now given as a practical illustration of the method in question. The case was worked out a few months after the reading of Mr. Barlow's paper.

Two points in the Line are as usual assumed—one at the crown and one at the springing. There is further (for convenience of solution) the arbitrary assumption that the Line of Pressure must be a curve of the fourth degree. This of course is not strictly accurate, although it may be correct enough in practice. The reader must also observe that *y* stands for horizontal measurement, and *x* for vertical,—which is the opposite sense to that in which we ourselves use these letters.

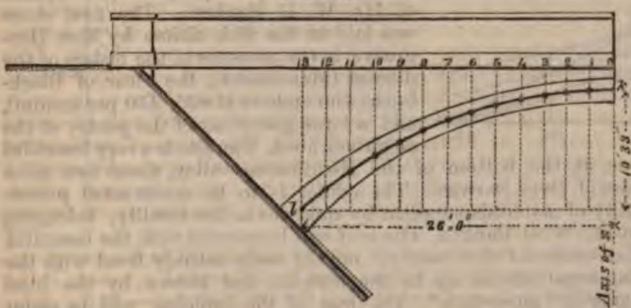
1. Reference.	2. Value of *y*.	3. Weight of each section for 1 foot in breadth, expressed in cubic feet of masonry.	4. Total weight (W) up to each No. for 1 foot in breadth.	5. Value of total weight (W) as calculated by the formula $W = 2{\cdot}755y -$ &c.	6. Value of *x*, calculated by the formula $x = {\cdot}0106y^2 -$ &c.
No.	Feet.	Cubic feet.	Cubic feet.	Cubic feet.	Feet.
0	0	......	0·00	0·00	0·00
1	2	5·39	5·39	5·44	0·04
2	4	5·52	10·91	10·91	0·16
3	6	5·79	16·70	16·64	0·37
4	8	6·32	23·02	22·87	0·68
5	10	7·03	30·05	29·85	1·08
6	12	7·93	37·98	37·81	1·60
7	14	8·98	46·96	46·99	2·25
8	16	10·35	57·31	57·64	3·05
9	18	12·01	69·32	70·00	4·03
10	20	13·94	83·26	84·10	5·20
11	22	16·35	99·61	100·78	6·63
12	24	19·45	119·06	119·68	8·32
13	26	23·04	142·10	141·26	10·33

In the above table the first column gives the reference numbers to the vertical lines of subdivision of the semi-arch, which are at intervals of 2 feet. The second column gives the horizontal distance *y*, measured from the half-span. The third column gives the weight of each section (including both masonry and loading) for a single foot in breadth: this weight being reduced into an equivalent in cubic feet of masonry. The fourth column gives the total weights from the crown downwards, for a foot in breadth, as found by the continuous addition of the figures in the preceding column. The fifth column shows what these total weights should be according to the assumed formula: it forms no step in the process, but is added to show the small amount of error involved in the assumption. The sixth column gives the calculated values of x, the vertical ordinate of the Line of Pressure.

The following is the method of arriving at the values of x, in the sixth column, from which the Line of Pressure (*lk*, Fig. 17) is plotted.

Assuming (as already remarked) that the Line of Pressure is a curve of the fourth degree, it would follow that the successive total weights given in the fourth column would be expressible in powers of y to the third degree in the form $W = Ay + By^2 + Cy^3$. Observing that when $y = 4$, $W = 10{\cdot}91$; when $y = 14$, $W = 46{\cdot}96$; and when $y = 24$, $W = 119{\cdot}06$ (see in the table, cols. 2 and 4, lines 2, 7, and 12); the usual process of elimination applied to the expression $W = Ay + By^2 + Cy^3$ gives the result that $A = 2{\cdot}755$, $B = -{\cdot}027$, and $C = {\cdot}005$. So that $W = 2{\cdot}755\,y - {\cdot}027\,y^2 + {\cdot}005\,y^3$, and by comparing the successive values of this expression in column 5 with the actual weights in column 4, it is seen that the above equation is very near the truth.

FIG. 17.



Let H = Horizontal Thrust. Then $H \times dx = W \times dy = (2{\cdot}755\,y - {\cdot}027\,y^2 + {\cdot}005\,y^3)\,dy$ (see Whewell's Mechanics, p. 164). Integrating,

$$H\,x = \frac{2{\cdot}755}{2}\,y^2 - \frac{{\cdot}027}{3}\,y^3 + \frac{{\cdot}005}{4}\,y^4 + K;$$

and when $y = 0$, $x = 0$; consequently K is = 0,

$$\therefore Hx = 1{\cdot}377\,y^2 - {\cdot}009\,y^3 + {\cdot}00125\,y^4.$$

Now if the Line of Pressure passes through the assumed points at the crown and springing, x must be $= 10{\cdot}33$, when $y = 26$. Substituting these values in the equation just given, we find on reduction that $H = 130{\cdot}1$. That is to say, the horizontal thrust for each foot in breadth of the arch is equal to the weight of 130·1 cubic feet of masonry. By putting for H its ascertained value, and dividing each side by it, the following equation is arrived at:—

$$x = {\cdot}0106\,y^2 - {\cdot}000069\,y^3 + {\cdot}00000960\,y^4;$$

and this gives the successive values of x in column 6, down to the last one, which, as already explained, was assumed at the outset of the process. The curve is then plotted in the usual way. Fig. 17 shows the semi-arch with the line of Pressure *lk*, as found by the process just detailed.

If it were required to draw a Line of Pressure with a different amount of rise, the corresponding value of H would have to be found, after which the proper coefficients in the expression for x would be obtained by dividing by H, in the same way as before.

This method gives the form of the Line of Pressure with a sufficient degree of accuracy, and perhaps not an unreasonable amount of labour. But it offers no special facilities for determining the Points of Rupture in cases of difficulty.

Let us now inquire how far it may be practicable to simplify the problem of drawing the Line of Pressure, by availing ourselves of the property which has been already noticed in it—namely, its resemblance to the curve of moments.

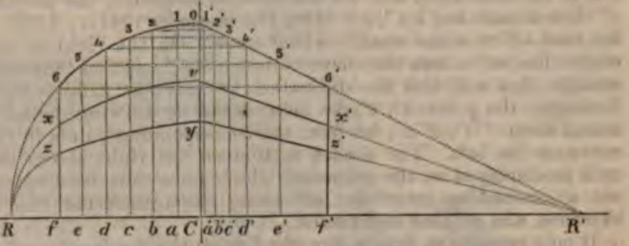
To return to an illustration already employed. Let it be supposed that an arc, 0 6 (Fig. 18), of a circle of the radius CR were given, and that it were required to draw a corresponding arc of an ellipse having for its semi-axis the radius CR. The arc of the ellipse is terminated by the same vertical lines (C 0, f 6) as the arc of the circle; and let it in the first place be imagined that the vertex (v) is given.

The first and obvious step will be to draw the equidistant ordinates a 1, b 2, c 3, &c., between C 0 and f 6, hitting the points 1, 2, 3, 4, and 5 in the circle. The elliptic arc vx will divide all these ordinates in a constant ratio. This being the case, it follows, that if the circle were *straightened out* into a right line, the ordinates being shifted to suitable distances, the ellipse would become a straight line too.

Produce the horizontal line RC to any convenient distance CR′ upon the opposite side of the centre line, and draw the straight line 0 R′ to this point from the vertex of the circle. Next, draw horizontal lines through the points 1, 2, 3, &c. in the arc of the circle, hitting the straight line 0 R′ in the points 1′, 2′, 3′, &c. Through these last found points draw the ordinates a' 1′, b' 2′, c' 3′, &c. These lines are then the ordinates a 1, b 2, c 3, transferred to the right of the centre line, and re-arranged at such distances that their ends come in one straight line 0 6′, which may therefore in one sense be called the arc 0 6 *rectified*. Draw the straight line $v\ x'$ R′, cutting f' 6′ in x'. Retransfer $f'\ x'$, and the other portions of ordinates cut off by $v\ x'$, to the left of the centre line, and their extremities will become points in the curved line vx, which is the arc of the ellipse required.

In the next place, let it be supposed that the vertex of the ellipse is not given, but only the horizontal semi-axis, and that it is required to find by trial such an ellipse as will satisfy certain conditions. If any other vertex, as y, is assumed, and the straight line $y\ z'$ R′ drawn, the ordinates cut off by this line will, when transferred to the other side, give another elliptic arc yz. As many trial ellipses as may prove necessary may therefore be obtained from the diagram by the easy process of drawing so many straight lines.

FIG. 18.



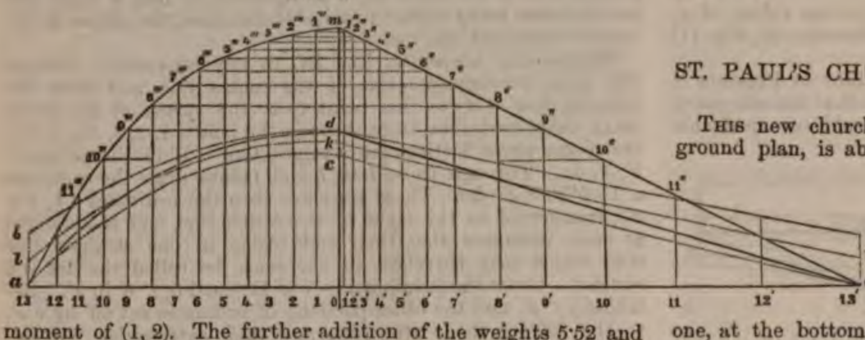
Now it has been already shown that the relation of the Line of Pressure to the Curve of Moments is the same that exists between the ellipse and the circle—namely, that the ordinates of the one curve bear a constant ratio to those of the other. The Curve of Moments, like the circle, is readily drawn. The Line of Pressure, like the ellipse, is not very easy to draw, even when its vertex and base are given, and when they are not, is to be found only by trial. Let us therefore see whether the expedient which has just been exemplified may not be fairly and usefully employed for determining the Line of Pressure.

1. Reference.	2. Value of x, or horizontal distance.	3. Weight of each section, as in previous table.	4. Moment of each section.	5. Total moment from springing up to any No.
No.	Feet.	Cubic feet.		
0	0	0·00	......	1341·24
1	2	5·39	5·39	1335·85
2	4	5·52	16·30	1319·55
3	6	5·79	27·61	1291·94
4	8	6·32	39·72	1252·22
5	10	7·03	53·07	1199·15
6	12	7·93	68·03	1131·12
7	14	8·98	84·94	1046·18
8	16	10·35	104·27	941·91
9	18	12·01	126·63	815·28
10	20	13·94	152·58	662·70
11	22	16·35	182·87	479·83
12	24	19·45	218·67	261·16
13	26	23·04	261·16	......

We will take the arch that has been already examined. The

Curve of Moments has first to be ascertained. The foregoing table gives in the third column the weight of each section, as in the previous table. The fourth column gives the moment of each section, which is found by adding the weights in the preceding column, after the method which has been fully explained in a former paper (see p. 64 *ante*). Thus, the moment of the topmost section (0, 1) is the same as its weight, 5·39. The addition to this moment of the weights 5·39 and 5·52 gives 16·30 for the moment of (1, 2). The further addition of the weights 5·52 and 5·79 gives the next moment 27·61, and so on. The fifth column gives the total moments from the springing up to any number, found by simple addition of the figures of the fourth column. We now revert to our usual system of calling the horizontal distance x (instead of y as in the first table).

Fig. 19.



Having thus very speedily ascertained the moments in the fifth column, the next step is to plot from them the Curve of Moments to the same horizontal scale that the arch is drawn to, using any arbitrary vertical scale that may be convenient. This is shown in Fig. 19, where the shaded section *abdc* shows the outline of the semi-arch, and *am* the curve of moments, the lengths of its ordinates *om*, 1 1‴, &c. being the numbers 1341.., 1335.., &c. read off to some small vertical scale. On the right of the centre line *m*0 is seen the curve of moments "rectified" into the straight line *ma'*, and the ordinates 1′1″, 2′2″, &c. arranged accordingly, the points 1″, 2″, &c. being found by drawing the horizontal lines 1‴1″, 2‴2″, &c. from the corresponding points in the curve on the left. The shaded section on the right shows the arch as displayed on the ordinates, which have thus been spaced out at increasing intervals: *db'* being the transferred line of extrados, and *ca'* that of intrados.

It only remains to draw a straight line on the displayed section of arch on the right, and then transfer to the left the points where it cuts the ordinates 1′1″, 2′2″, &c.; the result will be a line of pressure. If, for instance, the straight line *kl'* be drawn, cutting the centre of the keystone, and having a rise of 10·33 feet from *l'* to *k*, it will when transferred to the equidistant ordinates on the left give a line of pressure *kl*, practically the same as that determined by the approximate algebraic method previously given. Reasons have however already been shown for assigning a very different position to the theoretical line of pressure. It has been seen that it must meet extrados and intrados,—but without passing anywhere beyond either. The very obvious expedient of applying a straight-edge to the displayed arch will at once settle the question which is the line that satisfies these conditions. In the present case, *da'* is this line. On transferring it to the left side of the centre line, the line of pressure *ad* is obtained, which is therefore the one that accords with theory. It meets extrados at crown and intrados at springing.

Fig. 20.

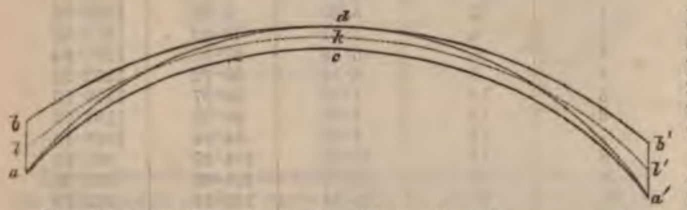


Fig. 20 shows the entire arch, with the line of pressure as just determined marked by the full line *ada'*. The dotted line *lkl'* is the line of pressure previously given.

The arch which has just been examined was a type of a numerous class on the South Wales Railway, designed by Mr. Brunel. The line of intrados is circular, flattened at the crown, and is most scientifically adapted to the permanent load and the manner of its distribution. In proof of this it is only necessary to notice the ***straightness*** of both intrados and extrados when displayed, as shown on the right of the centre line in Fig. 19. In circular arches of one radius, when displayed in the same manner, there will usually be observed a kind of ***curling up*** at the summit, indicating a point of rupture at some distance below the crown. (*To be continued.*)

ST. PAUL'S CHURCH, HODDLESDEN, LANCASHIRE.

(*With an Engraving.*)

This new church, of which we give a perspective view and ground plan, is about to be built, principally at the expense of Mr. W. B. Ranken. The first stone was laid on the 27th ultimo by Mrs. Hargreave, in the presence of the bishop of the diocese (Manchester), the vicar of Blackburn (who endows it with £50 per annum), and a large gathering of the gentry of the neighbourhood. The site is a very beautiful one, at the bottom of the Hoddlesden valley, about two miles east of Over-Darwen. The edifice is to be constructed principally of materials supplied by quarries in the locality, belonging to Mr. W. B. Ranken The roof will be covered with the beautiful slate-stone of the county, and the walls entirely freed with the flag-stone abounding in the district, and known by the local name of "pierpoints." The cost of the building will be about £6000. Local builders will be principally employed in the erection. The structure is from the designs of Mr. E. G. Paley, architect, Lancaster.

THE ARCHITECTURAL PUBLICATION SOCIETY.

The annual meeting of the subscribers to this society was held at 9, Conduit-street, Hanover-square, on the 30th of May, and we are happy to learn from the report then presented and the speeches delivered that this excellent society, though not supported to the extent which it deserves, is really making progress. We are desirous of drawing the attention of our readers to it, and to the publications which it has issued to its subscribers.

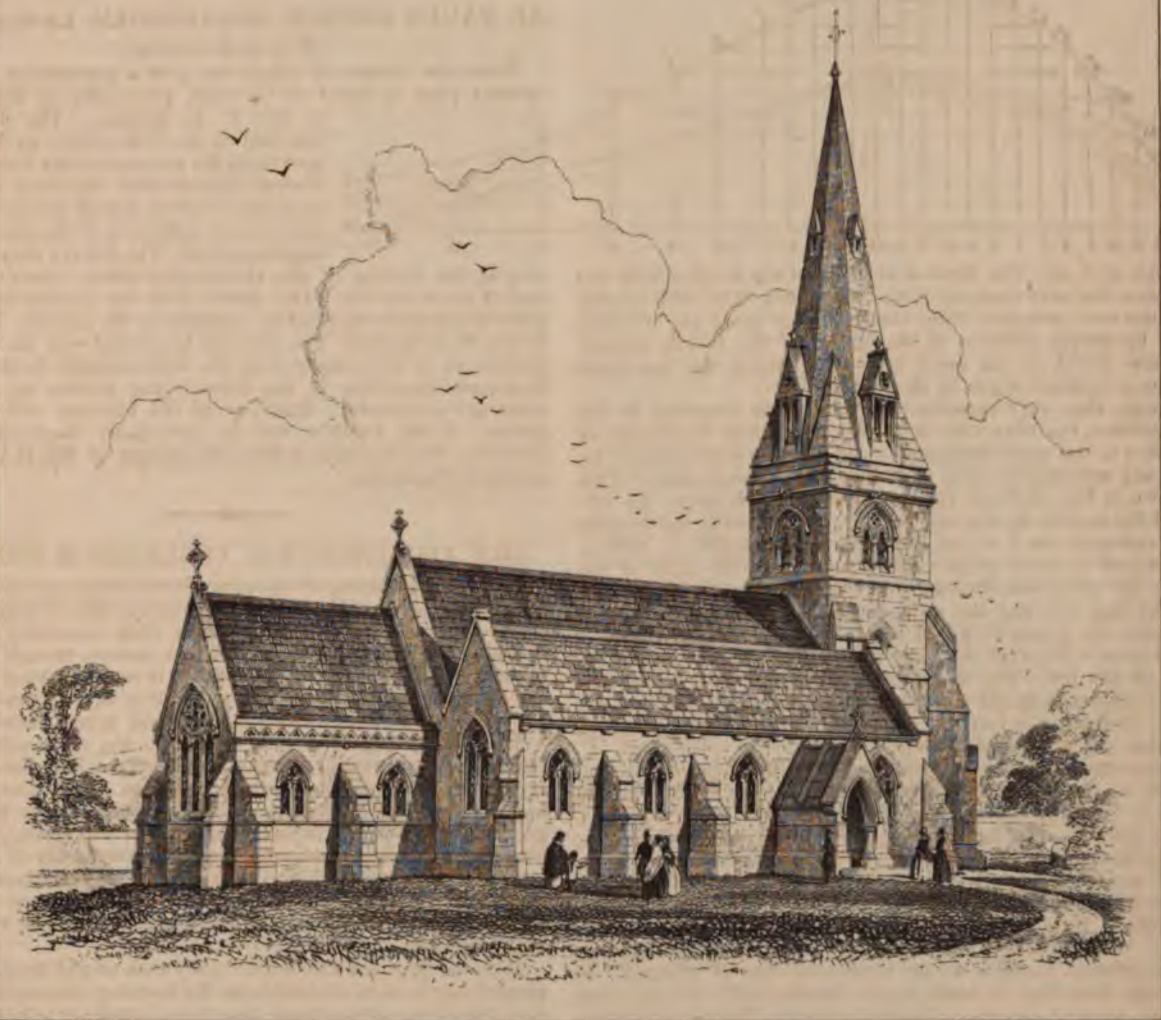
The society is formed with a view to the publication of engravings from original sketches, and of original writings on architecture. After the issue of a series of detached essays and sheets of illustrations, it was determined to give to the future publications so much of connectedness as was attainable by an alphabetical arrangement. Accordingly a Dictionary of Architecture was commenced in the year 1852, and the issues for the present year (the thirteenth of the society's operations) will, it is believed, bring both letterpress and illustrations down to the end of the letter K.

It is, perhaps, not too much to say that no publication of the present day is more creditable to the learning, accomplishments, and zeal of any class of men than this Dictionary is to the architects of the present generation. Written by a large number of contributors, the articles are uniformly distinguished for their clearness, comprehensiveness, and accuracy; while the illustrations, gathered from the portfolios of a still larger number of architects, are valuable for their artistic merit, and doubly so on account of their representing, to a large extent, buildings or works not elsewhere published.

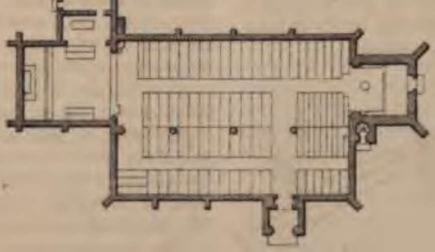
It is hardly necessary to add anything more in praise of the Dictionary, or by way of inducement to our readers to become supporters of the society. We have much pleasure in giving publicity to the invitation issued by the committee to all, whether members of the society or not, to communicate original information or sketches which might be useful in the Dictionary, and the publication of which they would be willing to permit.

The honorary and the acting committee comprise the majority of the most familiar names in the architectural profession. The treasurership for many years has been held by Prof. Donaldson, but has been lately resigned by him on account of ill-health, and is now held by Prof. Sydney Smirke, R.A. The hon. secretary is Mr. Arthur Cates; and the office of the society is at the Architectural Gallery, 9, Conduit-street, Hanover-square.

Pl. 24.



J.R.Jobbins. E.G.Paley, Archt.



ST PAULS CHURCH, HODDLESDEN.

ON THE REVIVAL OF STYLES.

By Rev. J. L. Petit.

(Concluded from page 198.)

If we are to consider the question between Gothic and Classic as a mere matter of taste (I mean arbitrary taste or fashion), we must bear in mind that this is notoriously liable to fluctuation. In the last century Addison spoke of the greatness (as regards effect) of the Pantheon in contrast with the meanness of a Gothic cathedral; and though it is not probable that the Gothic style will again be treated with the same contempt, yet it is by no means impossible that the relative estimation in which the two styles are now held will in the course of time be reversed.

What appears to me an insuperable obstacle to the general use of Gothic in the present day is that very quality which invests it with the greatest interest,—I mean, its expression of the tone of the particular period which witnessed its development, its culmination, and decline. And the restorer of Gothic seems to be liable to one of the following predicaments:—Either the style he produces is expressive of the thirteenth, fourteenth, and fifteenth centuries, and not of the nineteenth,—and then it is not Gothic, for Gothic is eminently expressive of the period in which it flourished; or his style is expressive of the nineteenth century,—and then it is not Gothic, for Gothic is expressive of the thirteenth, fourteenth, and fifteenth centuries; or his style has no expression at all,—and then it is not Gothic, for Gothic is an eminently expressive style. Nor do I see how he can escape from the dilemma, except by showing that the tone, spirit, character, state of civilisation and refinement, and stage of progress of the present century are identical with that of the mediæval period. If he can prove this he will overthrow my argument; but I suspect that the more he studies Mediæval architecture, and the history to which it forms an adjunct and commentary, the more difficult he will find his task. And I believe that this view of the subject has been taken by persons far more intimately acquainted with the matter than I can pretend to be.

It will perhaps be said that the same line of reasoning holds good with regard to all genuine architecture whatever. Unquestionably all great architectural works take their character from the period in which they were produced, and express it accordingly; but this may not be so much from the nature of the style itself, as from the manner of handling it. In Classic architecture we can in great measure separate the style from the building: the style may in itself have no individual expression, while the building has a great deal. In Mediæval architecture the style itself is expressive; and therefore, if transported to a period to which it does not belong, it runs the risk of expressing something which does not exist to be expressed, and consequently of being anomalous, and out of place. The Classic style, having no peculiar expression of its own, except that of refinement, may be endued by the architect with any expression his genius enables him to invest it with, and will readily receive and reflect the character of the age and people who adopt it.

Moreover, there is a greater affinity between our own age and country and those in which ancient Classic architecture flourished, than between ourselves and our Mediæval ancestors. Our tastes in art and literature are nearly identical. Take any fair specimen of our literary style—a leading article for instance in any established newspaper—and we shall find in it the same excellences which we should look for in a good writer of the Augustan age: clearness, force of expression, a happy choice of words, fluency, and harmony of rhythm, an avoidance of anything quaint or archaic, and an elegance resulting more from instinctive perception than from an elaborate selection and arrangement of phrases: these are beauties which must be obtained in a greater or less degree by every writer who intends to be read. And these are just the characteristics of good Classic Roman authors; so that we might introduce literally translated passages from Cicero, Sallust, or Cæsar, that shall altogether harmonise with our own natural style, and not appear in the slightest degree antiquated or obsolete. We read and enjoy Horace's odes, satires, and epistles, as if they were productions of our own day and our own country: we like them for themselves, and not merely as curious relics of the past. Nor should we feel that any poet who might form his style upon the study of these compositions was taking a retrograde step. So in sculpture: the student who wishes to attain eminence, and to advance his art, will exercise himself in copying or carefully studying the works of ancient Greek, Roman, and Renaissance artists; and though he will not neglect Gothic sculpture, he will not make it the great object of his attention, nor look to it as a standard of excellence.

I am speaking of literary composition and sculpture as arts which may be communicated and advanced, and in which we can mark certain stages, whether of progress, culmination, or decline; and I believe I may say, without fear of contradiction, we are not making a retrograde movement while we set up Classic models. Genius and inspiration may show themselves in any age, whatever be its state of refinement, nor can it fail of having an effect upon the progress of mankind; but we must not mistake the genius of an individual for national development. We should not look to Homeric Greece for a type of the Greek language in its completeness and purity; nor should we go back to the days of Giotto and the great Mediæval artists whose genius led up to the Renaissance for models of Italian art in its perfection.

But I must not dwell too long upon abstract points: we will take a more material view of the subject. The difference between the constructive principles of Classic and Gothic architecture is that the former professedly uses the beam or lintel—employing the arch rather as an expedient than as a predominant feature; while the latter may be said to be purely the architecture of the arch, admitting the lintel at rare intervals and on a small scale. But the artistical principles of the styles may be enunciated in a still broader and more summary manner. The Classic gives expression to the solids,—Gothic to the voids. Take a Greek colonnade: the columns, capitals, and entablature are carefully elaborated in their form and proportion, while the opening between them is left to itself, or its breadth determined upon with a view to the columns themselves, not to its own shape. In Gothic work, on the contrary, it is the form of the opening that engages the attention of the architect, the spandrels being the parts that in point of shape are left to shift for themselves. Hence the greater portion of Classic ornament finds its place on the surface of the wall, while the soffits and jambs—unless the depth of the arch be such as to give it the character of a vault—are comparatively plain. In Gothic work the decoration is mainly in the soffits—sometimes in the form of delicate and complicated mouldings, sometimes of flowers and foliage occupying the hollows, while the mouldings themselves branch out into foliation and tracery, filling the arch with beautiful patterns and figures. Even in the decoration of the surface the forms of the openings are repeated in blank arcades and panelling; and the enrichment of the piers themselves has reference rather to the arches they support than to their own importance as solid masses, or to the actual wall above them. The tendency of the Gothic system, as carried out in its works of the highest order—that is, in its cathedrals—is to the construction, or at least the suggestion, of a lantern of open-work—a vast frame of stone, in which the portions of flat wall are reduced to the smallest amount possible, such as the choir of Tournay Cathedral, which is so tender that it has been found necessary to connect every part together by ties of iron. Now in Roman work the pier or the wall itself is made to attract attention, while the arch or opening, whatever it may be, is a secondary and subordinate feature. Change all the arches of the Coliseum into square-headed openings—as those in the upper stage, as well as at Pola, actually are—and I suspect the change in its character would be much less than we are apt to imagine.

Now I am far from pronouncing the Gothic system to be wrong; and it is undoubtedly productive of great elegance, force, and spirit. But I would maintain that the Classic principle of giving expression to the walls themselves, rather than to the openings by which they are pierced, is architecturally sound. We build for the sake of what we get by the walls and the roofs they support—namely, seclusion and shelter; not for the sake of light and air, which we have in abundance without them. It is indeed necessary that we provide a sufficient supply of light and air, as well as means of access; but these are contingent necessities, not the main object of the building.

Again, the tendency of Classic is to breadth of effect; of Gothic to minute subdivisions, and an almost fantastic variety of outline. The traveller on the Continent will probably be struck, as he proceeds southwards, with the increasing breadth which characterises the towns, villages, and groups of buildings. He cannot fail to notice the preponderance, so to speak, of mass over outline. In a Mediæval town in the north of France, and in the greatest part of Germany, his attention will be caught by the number and variety of towers, spires, pinnacles, peaked gables and the like; on which great powers of design, as well as care in the execution of detail, are bestowed, while the mass itself is as much broken up as may be by openings and projections, which cause a constant play of light and shadow. In the south, he will have presented to him large and comparatively unbroken masses, marked by few openings or projections, with just a sufficient number of towers and spires to relieve the monotony of the outline, and these not displaying that architectural care or elaborate variety which would make it supposed they were intended to catch the eye, or form principal features in the group. In sketching an Italian village, or monastery with its church, we need not care about marking out all its windows, or putting them in their right places, or even giving to a nicety the form and proportions of the belfry, still less its details: in fact, the more slightly we define these, the more truly we shall give the character of the scene. Now, though these southern buildings and groups may be really in date just as Mediæval as the northern ones of which I have just spoken, they have more of the Classical character, which in Italy was retained in great measure through the whole of the middle ages: in fact, the composition of a large majority of Italian-Gothic buildings is such as to suggest no definite reason why Gothic details should have been employed in preference to Classical ones, so much does the horizontal line predominate. We may therefore fairly speak of this character of breadth as belonging to the Classic, and that of variety of outline and intricacy, or minute subdivision, as appertaining to the Gothic.

But although the Classical style does not peremptorily demand that variety of outline which is so necessary a part of Gothic, it by no means discards it as incompatible with its principles. Many steeples of the revived Italian are as fine in proportion, and as elaborate in detail as any Gothic composition. I may instance the upper part of the tower of Seville Cathedral, and many of Sir Christopher Wren's steeples, which show both the fertility of his imagination, and the comprehensive nature of the style he employed. I have on a former occasion adverted to the liability to decay incurred by the intricate and minute workmanship of Gothic ornament; and I understand that the condition of the ornamental details on the new Houses of Parliament is not such as to induce me to retract what I then said. But I would further remark that, although the constructive principles of the style are sound and good, so that, in many cases, the greatest amount of strengh is obtained by a given quantity of material, yet the tendency on the part of the architect to make a display of mechanical science, has been the cause of much real, as well as apparent weakness in important buildings. The lamentable fall of the Chichester steeple is probably to be attributed to the fault, not of construction, but of material. Yet it is certain that the perilous boldness of many Gothic designs insures more fearful results from the introduction of a defective piece of masonry, or unsound material, than are apt to occur in Classical buildings.

It may be said that the Gothic style can be worked in a broad and massive manner, as it was in castellated architecture; and to such an extent, that in adapting a Gothic castle, or an imitation of one, to domestic purposes, the difficulty is to avoid making the walls too solid, and the windows too few and contracted for comfort. But this mode of building was forced upon the architect by necessity, not adopted by choice. The requirements of military architecture rendered necessary this expansion of wall, and contraction of window, and the builder dealt with it as he best could. The harmony which exists between the dark heavy fortress and the light open cathedral, is a proof that both were designed in the natural style of the day, while the difficulty we feel in preserving the expression of the style in our domestic buildings, which require larger, and consequently more truly Gothic windows, than the Mediæval castles, is a proof that it is not the natural style of our own period. But the less display the Gothic makes of constructive science, and the less aid it borrows from such additions as pinnacles, tracery, and the like, and the greater the breadth and solidity of its masses, by so much the further does it recede from its own principles, and approach nearer to Classic architecture. An adaptation of the style to our own exigencies is not a development of it in its own proper direction, but an appropriation of some of the elements and characteristics of the rival style. We shall never develop Gothic further than it has already been developed, except by erecting buildings far less suited to our wants than Mediæval ones of the most exaggerated character. As it is, we seem to fancy that we can attain the life and vigour which constitutes the charm of the true Gothic, while we can only adapt it to our purposes by curtailing and cutting off the growth of many generations.

On the argument in favour of Gothic which rests on the superiority of decorated construction over constructed decoration, I cannot say much till I find myself better able than I am to comprehend the distinction. Is construction a term applied only to the more subtle contrivances of the architect, and not to a plain solid wall or pier, so that a mere wall enriched with surface ornaments is not a decorated construction? Are such pinnacles as those of Gloucester Cathedral and the Somersetshire churches, which are extremely beautiful in themselves, but in no way contribute to the strength or convenience of the building, decorated constructions or constructed decorations? Which term should we apply to pinnacles engaged in the sides of towers, or to blank arcades and panelling? If a square-headed window in a Classical front has over it a projecting ledge supported by brackets, and covered by a pediment, forming a tympanum, I suppose this would be called a constructed decoration; at least, I should call it so. How then, if a Gothic window has over it a label resting on heads or bosses, and crowned with an angular canopy, crocketed and terminated by a finial—a composition of constant occurrence in the finest works of the fourteenth century? Observe, the two compositions are perfectly analogous: it may be that the one is heavy and ugly, the other light and beautiful; but the principle is the same in both. I do not condemn surface ornament or constructed decoration in Gothic; only when it does occur let it be called by its right name, and not ignored for the sake of a plausible but somewhat fallacious argument.

We will now consider what ancient buildings are in existence, belonging to recognised styles, which suggest a mode of construction and arrangement applicable to our wants, and of decoration suitable to our best views of art.

If we look at the Parthenon of Athens, or the Temple of Neptune at Pæstum, we are impressed with its wonderful beauty, majesty, and sublimity; and as we acknowledge this to be the result of careful arrangement and adjustment of proportions, together with exquisite design shown in the simplest and smallest details, we cannot but treat with a certain degree of reverence the rules and principles which led to such a result; and, although we consider the plan of the building itself unsuitable to our purposes, yet we feel that it is well worth our while to study it diligently, and think how we may turn to account the lesson we cannot fail to learn. If we look at the Coliseum at Rome, and endeavour to forget the purpose for which it was erected, and the scenes which were enacted within its area, we must regard it as a work of almost unexampled magnificence, and at the same time admit that it presents a type of arrangement and ornamentation applicable to all tabulated structures whatever.

If, again, we look at a large Gothic cathedral—say, for instance, Amiens, Chartres, or Rheims; or, in our own country, York, Lincoln, or Salisbury, we cannot but be astonished by the grandeur of its design, the mechanical skill displayed in its construction, the richness of ornament which is profusely spread over it, and the character of religious solemnity which pervades the whole. Yet we cannot help feeling that it is not a structure likely to be called for or produced in the present day. Its associations belong to an age more sharply and distinctly separated from our own than are even those of Pagan antiquity. Its principles of composition are not adapted, without some modification, even to the large churches we demand, and are rather opposed than otherwise to the conditions required by secular architecture. As records of one of the most interesting phases of art and social progress that it is possible to conceive, the Mediæval buildings of Europe are invaluable, independently of the practical lessons to be derived from them; and to preserve them we must keep them in repair, which we are not likely to do unless we make what use of them we can. Fortunately, most of them can be made available to our purposes to a certain extent, though in large towns it has often been found expedient to destroy the old church and build a new one of more commodious arrangement; while how to make the most of our cathedrals is a problem that has more than once puzzled their restorers.

The architects of the Classical revival, seeing that their style must necessarily prevail in secular buildings, wisely and rightly adapted it also to their ecclesiastical buildings, still without making any material alteration in their plan or structure. They cut off, indeed, some of their superfluous ornament, and reduced them to an aspect resembling the Romanesque: to which style, indeed, we might easily attribute many churches of the revival, if we see them at a distance, and with some we might fall into the mistake even on a closer inspection.

This leads us to enter a little more fully upon the subject of general outline. That the Greeks were keenly alive to the picturesque, and probably had a more refined notion of it than any race of men before or after, we have good reason to suppose. The instinct with which they selected the finest sites for their buildings, and the scrupulous care with which they avoided interfering with the natural features of their scenery, as though hardly a rock could be cut away without offending some deity who presided over it, shows with how deep a feeling they were actuated on this point: a glance at the Acropolis of Athens, and the surrounding locality, convinces us of this quality of the Greek mind, even if we did not infer it from their love of country, or had not learnt it from Homer, Æschylus, and Sophocles. It is most likely their buildings were designed not only to harmonise with, but to illustrate, as it were, the character of their scenery. Certainly the rock of the Acropolis and the Parthenon seem made for each other: we could not fancy the temple in any other spot; and the rock without the temple would be imperfect. But it is likely that their feeling of the picturesque was of too refined a nature to suggest that they should aim at what we call a striking outline: it may have taught them to prefer one that might have been chargeable with monotony but for some exquisite tact in its composition; and that such buildings as the Choragic monument, formerly known as the lantern of Demosthenes, ought to occupy some low and secluded spot, instead of contributing ostentatiously to the variety of the sky-line. Of course, I can only speak from conjecture, for we have not sufficient data upon which to ground any theory on this subject. The massive forms however, and long horizontal lines, of their temples, indicate that they aimed at the expression of repose rather than violent action; and this is confirmed by the character of their sculpture.

Neither have we the means of judging what views with regard to outline influenced the Roman architect. The beautiful monument of St. Remy, in Provence, shows that the power of producing good form existed: the monuments at Vienne, on the Rhone, and Igel, near Treves, are less remarkable for their beauty, though the latter is not wholly destitute of grace. The triumphal arches of the Romans hardly, I think, show the elegance of which such structures might be capable: that however of Trajan, on the pier of Ancona, is an exception. The magnificent arch at Orange is more remarkable for the profusion and delicate execution of its ornament than for any excellence in its architectural design. At Athens there is an arch of Roman construction, I believe of Hadrian's date, of a lighter and more elegant design than the triumphal arches of Rome, but still of no very great beauty. Some of the Roman circular temples may have had a good outline, if the assumed restorations are at all true; and one at least we know to occupy as fine a site as can be imagined, and, in its present ruinous condition, to be well worthy of it: I mean the Sibyl's temple at Tivoli. The Pantheon at Rome can never have been a picturesque building. As antiquaries we may regret the addition of the modern turrets flanking the porch, but in an artistic point of view they could ill be spared. The temple of Minerva Medica forms a very picturesque ruin, and may have been no less so when perfect,—but I cannot help looking at this as a transitional specimen. In its use of buttresses it forestalls one of the great principles of Gothic construction. On the whole, if we were to assume that the general outline of ancient Rome was less varied and interesting than that of modern Rome, and that the effect produced on the spectator would depend rather on masses of building occupying sites of different elevation, than on prominent architectural features, no one could easily find grounds on which to contradict the assumption. But the revivers of the style have taught us that it is fitted for an outline of the greatest beauty and sublimity, and capable of a picturesqueness of composition not surpassed in the best Mediæval period. And this shows that their work was really a revival, and not a mere formal reproduction. In tracing the development and progress of taste in the composition of outline, we shall advert chiefly to ecclesiastical architecture, because it affords us examples in greater number and in better preservation than any other kind; and also because it has less restricted art by mere economical or utilitarian considerations.

I am inclined to think that the circular churches, derived from Roman temples of the same form, are the first which exhibit that kind of outline which is produced by the central tower or dome, and which has characterised churches of the highest class ever since. The Eastern form however of the Greek cross, with the dome or tower at the intersection, is evidently a very early one—perhaps the earliest original form of a church that exists; for it does not appear to have been derived, like the basilica and round church, from Pagan structures.

The solution of the problem, how to adapt a spherical dome to a square area, must have introduced a new era in architectural composition. The value of the dome had long been recognised as a method of roofing at once firm, permanent, economical, and beautiful; but, so far as we have the means of knowing, it had hitherto been used only to cover buildings of a corresponding form, as the Pantheon. The cruciform plan seems also to have been introduced, to a certain degree for the sake of convenience, into the Roman basilica, and its symbolical meaning would give it an additional recommendation in the eyes of the early Christians; but the roof throughout being generally flat, the square of intersection would be treated in the same way as the arms or aisles of the building, and neither receive nor suggest any additional height, externally or internally. When however it was resolved to take advantage of the domical method in roofing the square of intersection, making the other roofs of the building cylindrical or semidomical, according as the limbs of the cross were rectangular or apsidal, then, since the base of the dome had to rest by means of pendentives on the crown of the four arches, its apex necessarily exceeded them in height, and consequently rose above the vaultings, supposing them to correspond with the arches of intersection. This is true, not only when the dome is a complete hemisphere supported by pendentives, but also where it is a part of the same hemisphere to which the pendentives themselves belong, or any other segment of a sphere whatever. Hence the adaptation of a dome to the square of intersection in a cross church requires a superstructure raised higher than the arches, and consequently suggests one raised higher than the walls and the roof, both externally and internally.

Probably St. Sophia at Constantinople was not the first example of a dome resting on four arches; so bold an experiment could hardly have been tried on so large a scale for the first time. Many of the domical churches in the eastern parts of Europe are small in their dimensions, and have no architectural detail but what might be of considerable antiquity. If we cannot confidently pronounce any particular specimen to be of a date earlier than the reign of Justinian, we cannot positively deny the existence of such at the present day; and we may at least assume that those to which we now have access are fair representatives of some of the earliest original Christian structures ever designed. St. Sophia is somewhat unique among Byzantine churches, and has rather the character of the mosques which surround it, and which were built after its pattern, than of the churches generally erected in the East at that time and for many succeeding centuries. St. Irene, now converted into an armoury, is the next in size to St. Sophia of those in Constantinople, but very much inferior in dimensions, the diameter of the dome being, if I remember right, less than one-third. I cannot tell how far the present outline is original; it is perhaps the more pleasing of the two. The outlines of some of the old Greek churches in Constantinople, and in and about Athens, are extremely graceful—I may say noble—as giving to structures small in actual scale an air of dignity and importance. The central dome assumes the form of a circular or polygonal tower, of some elevation, and there is a certain breadth about the composition that prevents any idea of meanness. The actual ground-plan is square, but the upper stage, from which the dome or tower rises, is a Greek cross. To the westward is a narthex or porch, which is sometimes covered with another dome, lower than the principal one. The pendentives supporting the dome required themselves the support, abutment, and protection of the walls above the springs and haunches of the arches on which they rested; and by raising these walls above the crown of the arches additional strength was given, and the whole fabric consolidated. Hence the round or polygonal drum of the dome mostly stands upon a square base, slightly raised above the level of the other walls; and when the central dome was adopted, as it soon was, in the western church, at the intersection of a Latin cross, the square base often became a square tower, inclosing within itself a circular or polygonal dome, which then formed only an internal feature. This is an arrangement which prevails through the whole of the south of France, and in parts of the central and more northern provinces. In Italy the central tower is generally a low octagon. As a satisfactory outline was thus obtained, the central tower was used even when no dome or lantern was shown internally.

If a campanile was required, this was provided, not by raising the central lantern to the requisite height, but by building an independent tower, as in the basilican churches. The combination of the central lantern with the belfry tower produces some of the finest and most picturesque effects of outline in ecclesiastical architecture. Such combinations are mostly to be found in the Romanesque period. I think we meet with them more often in Italy than in France, where the central tower first attained sufficient height to cover the lantern, and afterwards grew still higher, and became the highest and principal steeple in the church. Whether this was an improvement is a matter of taste. For my own part, I am very partial to a fine central tower or spire, but I am not certain whether, on true architectural principles, we ought not to prefer the low massive lantern of the Italian-Romanesque, combined with the taller and more slender campanile; the central lantern giving by its breadth dignity to the most important part of the building—namely, the intersection of the cross, and the lofty tower giving the same feature value by its contrast, and breaking the monotony of outline. Added to which, the arrangement is evidently a good one as regards convenience, by detaching the belfry from the area of the church, and allowing walls of any degree of massiveness that may be required. The Cathedrals of Piacenza and Parma, the Cathedral and another church at Asti, many of the churches in and near Pavia and Milan, and the Cathedral of Monza, present fine examples of the above arrangement: some of these are later than the Romanesque era, but retain in great measure the general character of the style. In England we have unfortunately so little unmixed and unaltered Romanesque, or, as I would rather call it, Norman, that it is difficult even to imagine a typical example, and such buildings as Tewkesbury, Southwell, and Romsey, show how grand must have been the outline of a perfect English church of the first class in that period. But Normandy furnishes us with better preserved examples of the style, from which we may form an estimate of its general aspect and character. The well-known church of St. George, Bocherville, is I believe as pure a specimen as can be found, and its outline, simple as it is, seems to admit of no improvement. It may be questioned whether the present wooden spire agrees with the original design: I am however speaking of the building so far as the actual masonry and the necessary roofs are concerned. I question whether the development of the Pointed Gothic really improved upon the best outlines exhibited in the Romanesque. It certainly gave greater height, and varied—perhaps confused—the general outline of the building by pinnacles and buttresses. Where the central tower was retained it was frequently raised to a greater height than its use as a lantern rendered necessary. The central tower of York, which is open nearly to the top, is an exceptional instance rather than a type of Gothic central towers, and is unquestionably one of the finest, if not the very finest in existence; and it is certainly one of those that are least removed from the Romanesque model.

Again, on the Continent the central tower was altogether sacrificed to the attainment of height in the whole building itself, which in consequence often appeared rather a shapeless mass than a fine architectural composition. The profusion of pinnacles employed seemed rather intended to disguise the want of design than to mark as they ought to do important points and divisions. Some of the best outlines in Normandy, comprehending the low central tower, and loftier but less massive western ones, though Gothic in detail, as that of Lisieux, are wholly Romanesque in character, and those which assume more of the Gothic are not improvements. The heightening of the English central steeple, though the effect resulting from it is sometimes extremely beautiful, as at Salisbury, is seldom carried out without some sacrifice as regards internal arrangement or actual security. I am quite aware that we find many ugly buildings, and many buildings of a fantastic outline, that belong to the Romanesque period. In Germany, and even in France, I could point out both one and the other; but it is certain that in that period a very beautiful type of composition appeared, the simplicity of which, and its independence of additional ornament, stamps it with a degree of refinement which is scarcely preserved in the more advanced stages of Mediæval architecture, when features of mere decoration became abundant. The best architects of the Renaissance evidently felt this, and in their ecclesiastical structures, for which they found no available precedent in ancient Classical architecture, they returned to this Romanesque type, and in a short space of time a large number of churches were erected, showing a full appreciation of those early models. Many would at a short distance be taken for buildings of a date anterior to the thirteenth century. The cathedral of Dax, south of Bordeaux, would at first sight be pronounced Romanesque: it is, in fact, Revived Italian, except an incomplete Gothic tower at the west end. At a village between Epernay and Rheims I noticed a church at a distance which I made sure of as a fine Romanesque specimen. On examining it I found it clearly post-Gothic. I may have been disappointed at the time, but it now proves valuable to me as an example.

When I had the honour of reading a paper at the South Kensington Museum, rather more than a year ago, I showed some drawings of Spanish churches in the Revived Italian style whose general outline had altogether a Romanesque character. I am still of opinion that these churches might be studied to advantage in the present day, as securing really fine architectural features at little or no sacrifice of convenience, and at no exorbitant expense. In Italy the combination of the low lantern tower with the lofty campanile was continually reproduced; and still further grandeur was obtained by expanding the central lantern into a spacious dome, which became the predominant feature both externally and internally. Such domes had indeed been more than suggested by the early Byzantine and circular churches, but the revivers of Classic art worked them out with an elaborate care in regard to proportion, and often with a success, which almost reminds us of the elaboration of the column in Greece. That of St. Peter's, as it is the largest, is to my mind the finest example that can be brought forward. I have endeavoured to procure a tolerably true outline, comparing my own sketch with an engraving that appeared to me a very exact architectural elevation, and making corrections accordingly. Many prints and drawings make it too round and heavy, and most of the photographs I have seen are taken from a point that does not show it to the best advantage. But though St. Peter's is the finest example, it is but one out of a vast number, which exhibit a great variety of forms and proportions, nearly all of them pleasing to the eye, and giving quite as much character to the Italian landscape as the Gothic tower or spire does to the English.

Had the dome been congenial to the Gothic, it would surely have been introduced in that style, a style which certainly is not chargeable with timidity in adopting new forms and combinations. The arrangement of the central part of Ely Cathedral offered opportunity for its adoption: yet we find an octagon, with a Gothic vaulting adapted to it in the best way the architect could devise, and that architect was one of more than ordinary fertility of resource.

Without for a moment depreciating the grandeur of a fine Gothic interior, I must observe that the Classic style contains elements of at least equal grandeur, if not greater. The churches of St. Andrea in Mantua, St. Justina and the Cathedral in Padua, are not inferior in solemnity of effect to any Gothic edifice whatever. Had St. Paul's been carried out according to the design preserved by the model, I can conceive of no design that would have been equal to it. An impression of vastness would have been produced by means totally opposite to those employed in Gothic, and, to judge from the model, even more effective; while the variety of perspective views, and the fine alternation of light and shade in broad masses, would have given a picturesqueness scarcely rivalled in the eminently picturesque Mediæval styles. If I am right in believing that there is a picturesqueness of repose as well as of action—a picturesqueness depending rather on breadth and mass than on intricacy and multiplicity of parts, then I cannot be wrong in asserting that the Classic may meet the Gothic, even on its own ground, on at least equal terms.

Still, if constructive considerations should render a pointed arch desirable under any circumstances, its admission does not necessarily involve that of the whole Gothic system. The pointed arch was used before Gothic was developed, and in localities which were the last to receive the Gothic style. Saracenic architecture has the pointed arch, but it is not Gothic; neither are those domical buildings in Aquitania which employ the pointed arch, without an approach to Gothic mouldings, in the support of their pendentives. But even supposing the pointed arch to have belonged exclusively to the Gothic, we may borrow it if we really want it, without professing to revive the style. It is not an architecture to pass away without influencing any succeeding style: we are not obliged to choose between accepting all or none. There is one very important element of Gothic which we should be foolish to reject, and of which, if I mistake not, the Renaissance architects saw the value, and by its means considerably modified the rigidity which might have resulted from a strict imitation of the ancient Classic,—I mean the oblique surface of decoration. The use of this much facilitates the enrichment of our buildings, while we exclude heavy and incongruous ornament, and enables us to retain such beauties of Gothic sculpture as are not inconsistent with a more severe and refined style.

As, in advocating the revived Classical style, I would not urge the rejection of everything which belongs to the Gothic, still less am I anxious to defend the glaring defects which characterise so many specimens of the Classic. I would not perpetuate the cold formality of most of our professed imitations of the Greek; nor the feeble, unmeaning, uninteresting character which prevails in so much of our work that claims a derivation from the Roman. But a discussion upon the defects that may be enumerated in Classical buildings, and upon the causes which independently of Mediæval sentiment have tended to bring the Classical style into disrepute, would occupy a great length of time, and I am not sufficiently master of the subject to enter fully into it. I believe however the greatest defects in the style are of a superficial character, and admit of removal. By clearing them away we shall give it a vitality and vigour which its evident congruity with the practical spirit of the age cannot fail to preserve; while the consistent stability of its nature—the very reverse of that restless tendency to change which is one of the essential elements of Gothic—will make it a permanently effective style, at least till the present conditions of society become altogether changed.

RAILWAYS IN INDIA.

The annual report on the railways in India, presented to Parliament, has just been printed. It is accompanied by a map of India, showing the lines of railway completed at the end of last year, those in the course of construction, and those projected; from a glimpse of which it appears that the lines actually open bear a very small proportion to those in progress. This view of the state of Indian railways looks, indeed, very discouraging, for no one line is finished, and only comparatively small lengths of railway in different parts of the vast tract of country on which they are traced are marked as having been opened for traffic. This discouraging-looking state of things may be attributed to having commenced so many and such extensive works in different parts of the peninsula, instead of concentrating them on one or two of the most importance. The actual condition of the Indian railways is not however so bad as it appears on the map, for although only 842 miles in different sections had been opened of the 3738 miles that have been commenced, the railways are in such a state of progress that it is expected 1317 additional miles will be opened in the course of the present year, and 1147 in 1862. The cost of construction has hitherto greatly exceeded the estimates, and the assumed cost of £12,000 per mile, on which the profits had been estimated, will actually amount to £16,000. The necessity for obtaining materials from this country has of course added greatly to the cost. In the course of last year the materials sent from England amounted to 234,710 tons, their value being no less than £2,140,703, but as the various lines approach completion the amount of materials required from England will rapidly diminish. Some very formidable works have yet to be finished, especially on the East India Railway, from Calcutta to Delhi. Of these, the Monghyr Tunnel, the Soane Bridge, and the Karumnassa Bridge, were inspected by the Governor General in December last, and they are described by him in a letter in the appendix. A great part of the tunnel has to be excavated through quartz rock, and, though only 900 feet long, it has proved a very laborious and costly undertaking. Lord Canning expresses the opinion that it was not necessary to undertake it, as the tunnel only saves three miles in the whole distance. The Soane Bridge is a work of great magnitude and difficulty. It is to consist of 27 lattice spans of 150 feet each, and, including the abutments, the bridge will be nearly a mile long. Each pier is to stand "on three wells of 18 feet diameter." The wells of all the piers had been sunk through 30 feet of sand to the stratum of clay beneath. The stupendous works on the Bhore Ghaut Railway Incline, 15 miles long, and including 2535 yards of tunnelling, and on the Thul Ghaut Incline, 9 miles 26 chains long, both on the railway that is to connect Calcutta and Bombay, have been previously noticed in our Journal, in papers by Mr. J. J. Berkley, the chief engineer.

The financial position of the Indian railway companies is at present an important consideration, as many of them require the direct assistance of the government for their completion. When the report of last year was made it had been estimated that the railways would be completed for a sum of £52,430,000; but according to fresh estimates, since made, it appears that nearly £56,000,000 will be the amount required. On the 30th of April last, it is stated that £34,396,445 had been raised by the railway companies, and £34,042,128 had been expended. Of the sum yet required, the distribution of it over the next three or four years, and the sources whence the money is expected to be derived, are thus stated:—

		England.	India.
In 1861-62,	£8,000,000	£2,000,000	£6,000,000
1862-63,	4,000,000	750,000	3,250,000
1863-64,	1,500,000	300,000	1,200,000
1864-65,	500,000	100,000	400,000

When the works already in progress are completed, the consideration will arise, whether the postponed works should be then proceeded with, at a further expenditure of eight millions sterling. The receipts on the sections of railways already opened cannot be taken as indicating the amount of traffic that may be expected when the lines are completed, but so far as any opinion can be formed from such partial openings of railway communication it is satisfactory. The number of passengers carried during 1859 was upwards of three millions; and the annual earnings on the 30th June last amounted to about £318,310. As might be expected on the first opening of railways in such a country as India, there was a large proportion of accidents, caused principally by engines and carriages leaving the rails, though the number of lives lost was comparatively small. In 1859, the last year for which there are returns, there were 29 occurrences of that kind, of which 21 were on the railway from Bombay to Sholapoor, but the number of passengers killed on all the Indian railways during the same period did not exceed nine. The report, which is ably drawn up by Mr. Danvers, secretary to the Railway Department at the India Office, concludes as follows:—

"It will be seen by the statements which have been given above, that now the only impediment to the development of the railway system in India is the apprehended difficulty in supplying funds. The physical and engineering obstacles which presented themselves, if they have not been entirely overcome, are in a fair way of being surmounted. Rivers of great width and depth are being spanned by bridges which will stand as monuments of the scientific skill of the present age; mountains will be crossed by means of works which of their kind will be unrivalled; swamps and jungles have been drained and cleared, and hills have been pierced. All this has been done with British capital, but its flow in the same direction, through the appointed channels, has for a time sustained a check. And this is not altogether to be wondered at, when the disturbing influences of the last few years are taken into consideration. For a long period the funds raised by the companies were abundant, and balances of considerable amount usually stood to their credit. There is no reason to suppose that this steady supply would not have continued had it not been for the political convulsions which have taken place. The excessive expenditure caused by the mutiny forced the government to contract large loans, which naturally interfered with the financial operations of the companies. This may be regarded as a temporary cause which will pass away; but it was not possible to wait for more favourable times without incurring serious loss. While the difficulties have been increasing the works have been prosecuted, and have now arrived at that stage in their progress which demands an outlay during the present year as large as last year, and higher than will be required in any subsequent year. The future progress and early success of these great works depend, then, upon the financial arrangements that may be made to meet the expenditure requisite to bring them into a profitable condition. It has all along been necessary to extend the support of the government to the companies which have undertaken them. Assistance has been given in the shape of a guarantee of interest upon the capital, and with this help more than thirty-four millions have been raised. Upwards of two more can be raised by calls upon issued shares, and, if the state of the money market improves, further amounts may be obtained by debentures and additional shares. But if the expenditure is at a rate more rapid than that at which capital can be raised by these means, it may be necessary to have recourse to government aid in the shape of advances. The charge upon the state involved in this arrangement will not be more than it now is, and the risk to the government will not be greater, as the conditions of the contracts remain unaffected by it. There can be no doubt that the best policy to be pursued, under existing circumstances, is that which has been decided on—viz. to proceed steadily with the works which are in progress, and to raise funds as required—if the companies fail to do so—through the direct agency of the government; to postpone, but only temporarily, works which have not been commenced; and to guarantee no further projects until the lines already sanctioned have been completed.

The interests alike of the government, the railway companies, and of the public would be sacrificed by the suspension of operations in the present condition of the lines. Not only would a large outlay remain unprofitable, but positive loss would be incurred by the damage to, and even destruction of, unfinished works, if left to the mercy of the elements in a tropical climate. Never, perhaps, was there a time more pregnant than the present with proofs of the necessity for a sure and permanent system of internal communication in India. Whether we look to the lamentable accounts of the famine now desolating the North-West Provinces, or to the anxiety with which passing events in America are being watched by our manufacturers, and to the temporary and necessarily imperfect measures which are being taken by the local governments to aid the transport of Indian cotton to this country; or whether, adverting to the large European force now destined to garrison the country, we consider, the safety, ease, and economy which would be secured by the conveyance of troops by railway, the early completion of the main lines which have been sanctioned appears to be a matter of paramount importance, and to admit of no delay."

NEW CHURCH, HIGHAM, SUFFOLK.

The small village of Higham, attached to the parish of Gazeley, and situate about two miles distant, has until recently been wholly without church accommodation. This want has just been supplied by the erection of a building in size to meet the requirements of the place, and in architectural propriety and character a kind of model edifice. This church, which is dedicated to St. Peter, was consecrated on the 27th of June. The arrangements of the plan are quite simple, consisting of a nave and north aisle separated by an arcade of four bays, a duly proportioned chancel, with organ chamber and vestry added, as a kind of continuation of the aisle, alongside of the chancel. There is also a spacious south porch, and a tower at the west end. This tower is of a form unusual in modern times, though there are several old ones of the kind in that locality, being quite circular on plan, as at Snailwell, Risby, and Little Saxham, and having a small staircase (also circular) communicating with the ringing chamber above. Its diameter is 20 feet at the base, the walls being 4 feet thick, and in height it is divided into three stages; the lower (open to the church, and serving as a baptistery) will have stone groining, springing from four small corbelled shafts, with moulded capitals and bases. The ringing floor is perfectly plain, being marked only by a small loop window on the west, north, and south sides; above this chamber is a string-course or set-off, upon which rest the bases of the series of columns and arches which surround the belfry stage, which of course clears the ridge of the nave roof. The belfry windows are single-lights, with tracery in the heads, and they face the cardinal points. A corbelled cornice and parapet complete the height of the tower itself, which will be surmounted by a low conical roof, having four lucarnes, and covered, like the rest of the church, with tiles. The porch has a richly-moulded entrance arch, and above the apex is a geometrical circular-pattern ornament, carefully worked in stone and napped flints: the side lights to the porch consist of two quatrefoils each. A north door faces the south entrance to the church, and there is also an external door to the vestry.

The east window is of three lights, richly moulded and shafted, those within being of Purbeck marble and having foliated caps. In the head are three circles, two of which are cusped with sexfoils, and one with a cinquefoil. The south windows both of nave and chancel are all of two-lights, and have tracery in keeping with the east window, being alternately sexfoils and quatrefoils in circles over the trefoil heads. The aisle is lighted by three coupled lancet windows on the north side, and a larger window at the west end. The roofs of nave and chancel are high-pitched, the former composed of polygonal rafters with tie-beams, having shafted king-posts at suitable distances. The chancel roof consists of a succession of curved rafters; the aisle has a lean-to roof, and, like the others, has its timbers exposed to view. The whole of the seats are of open framing—in the nave of red pine, in the chancel of oak.

The chancel arch is boldly designed, and has some exquisite carving in its capitals. The organ-chamber opens both into the aisle and chancel by corbelled arches, which are also handsomely carved. The piers between the nave and aisle are octagonal, and have moulded capitals and bases. The pulpit stands in the north angle against the chancel arch, and is also of octagonal form. The upper part is of stone, two of the exposed sides being carved with the heads of St. Peter and St. Paul in sunk quatrefoils; the lower part consists of a cluster of marble columns round a central pier, and this variety of materials and colours produces a very satisfactory effect. The same ideas have been observed in designing the font, which is circular, the bowl being of stone, and resting on marble shafts.

Owing to the space occupied by the east window, that left for a reredos is necessarily limited, but what has been done is in excellent keeping with the other decorative internal features. There is a continuous alabaster panel, corresponding with the length of the table, and reaching up to the string under the east window sill. In its centre is a circular sunk panel, with a Maltese cross inlaid in Galway marble, while on each side are two long panels, also sunk, and inlaid with various marbles in a small chequered pattern. The remainder of the east wall up to the same height is filled in with an effective arrangement of red, black, and green glazed tiles, with inter-bandings of Mansfield stone. The church is paved with plain red and black tiles, laid in a cross pattern; the sacrarium being of Minton's mosaic tiles. The walls are throughout of flint, with bandings of Ancaster stone, which is also used in the dressings generally.

The architect employed was Mr. Gilbert Scott, of London: the flint walling and masonry being executed by Messrs. Holland of Gazeley, and Rattee and Kett of Cambridge, jointly; and the woodwork, as also the carving generally, by the latter firm alone. The pulpit and font were executed by Mr. Farmer, of London, and the reredos by Mr. Field, of Parliament-street, London.

NEW THEORY OF THE FIGURE OF THE EARTH.

By F. C. Bakewell.

Having directed my attention for some time past to the actions of gravitation and of what is called centrifugal force on the surface of a solid globe when in rotation, I have arrived at conclusions respecting their effects on the figure of the earth directly at variance with the theory generally accepted. As I have arrived at those conclusions from a careful examination of the laws which govern the attraction of gravitation and centrifugal force, I presume to hope that the considerations which have led to them will meet with candid attention.

It is generally received as an established truth that the rotation of a solid globe about its axis tends to accumulate the loose surface-matter *at the Equator*. My object is to prove that, on the contrary, the *tendency* of the rotation of such a globe is to accumulate particles of matter on the surface *at the poles*. I do not, of course, deny that the figure of the earth is an oblate spheroid, nor do I deny that it received that figure by the action of centrifugal force, but I maintain that such a figure could only have been given to it by rotation when the mass, or a great part of it, was *in a fluid state*.

That proposition is based on the self-evident truth, that a body perfectly free will move in the direction towards which it is most strongly attracted or impelled. An eminent mathematician, to whom I submitted my views respecting the figure of the earth, did indeed at first deny, and afterwards cavilled at that truth, but it is so manifestly clear, being in fact only another expression of one of the laws of motion, that I take it for granted as generally admitted. In accordance with that axiom of mechanical science, I assume that water on the surface of a solid sphere will flow towards the part where it is most strongly attracted. Therefore, as the effect of the rotation of such a sphere would be to diminish the attraction of gravitation on the surface, and to diminish it most where the velocity of rotation was the greatest, all bodies free to move would be attracted towards those points where the velocity of rotation was least rapid; or, in other words, towards those points where the attraction of gravitation was the strongest. There would consequently be a greater accumulation of water at the poles than at the Equator.

To the proposition thus briefly demonstrated I think I might be justified in claiming general assent, and it seems difficult to conceive how anyone acquainted with the facts can have arrived at a contrary conclusion; but as that theorem is opposed to the opinion hitherto entertained on the subject, it is incumbent on me to do something more than append to it the initials Q.E.D.

Before arguing the question further it is desirable to state distinctly what is the existing belief in the scientific world of the tendency of centrifugal force to accumulate matter on the surface of the globe. This has been done so broadly and clearly by Sir John Herschel in his 'Outlines of Astronomy,' that I cannot do better than accept that distinguished philosopher as the exponent of the general opinion on that subject.

Sir John Herschel, after considering what would be the effect of gravitation on a solid sphere at rest, if converted into a spheroid by taking matter from the poles and piling it up at the Equator, next considers the sphere put in rotation, at the rate of one revolution in twenty-four hours. In that case, he says, "a centrifugal force would be thus generated whose general tendency would be to urge the water at every point of the surface to recede from the axis;" and the consequence would be, that solid matter would, by the action of the water, be gradually carried towards the equator, "to remodel the surface of the solid nucleus in correspondence with the form of equilibrium." It is still more strongly stated by Maclaurin, when considering the same proposition, that the water would recede so far from the axis as "to leave the polar regions elevated many miles above the level of the sea."

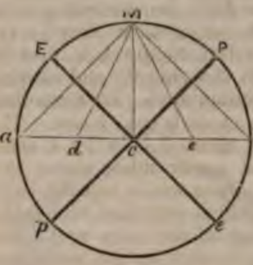
No cause is assigned by those eminent philosophers, beyond the action of centrifugal force, why the water should leave the poles towards which it is most strongly attracted to flow to that part of the surface where the attraction is the least; yet it is admitted, at the same time, that the action of centrifugal force is the cause of the diminution of attraction at the Equator. In other words, the assumption that the rotation of the solid sphere would cause water to recede from the axis to the equator involves the absurdity that the same cause which diminishes the attraction also increases it at the same point.

In order to show in a popular manner the effect of centrifugal force in diminishing the weight of bodies at the Equator, Sir John Herschel has recourse to an illustration, which, at the same time that it renders that effect more manifest, may serve to refute the hypothesis he has expounded; therefore I will press it into my service. He assumes a cord to be supported on props and pulleys along a meridian from the Equator to one of the poles, with a weight suspended at each end. In that case, he observes, it would require a larger weight at the Equator to counterbalance a smaller one at the pole. Now if, instead of unequal weights, we suppose exactly similar masses of the same metal to be suspended at each end of the cord, the mass at the pole would preponderate, and be drawn to the ground, and it would draw the cord along with it. Every particle of the cord along that meridian would thus be drawn towards the pole by the superior attraction of gravitation; and in like manner any other body free to move would be impelled in the same direction. The effect would be similar, though of course less in degree, at any intermediate points of the meridian. Even at the distance of a mile apart, the weight nearer the pole would draw down the other one, if the apparatus were sufficiently delicate to indicate the minute variations of attractive force at the two stations. It seems strange that in proposing the illustration of the cord and different weights, so trifling a modification of it as the assumption of equal weights should not have occurred to Sir John Herschel, by which the effect of centrifugal action in attracting matter towards the poles is as clearly exhibited as its effect in diminishing the weight of bodies at the Equator: both effects being, as I maintain, one and the same.

It being generally admitted that the rotation of the globe diminishes the weight of bodies at the Equator in a greater degree than at the poles, it will facilitate the demonstration of my proposition to examine in what manner centrifugal action produces that effect; but before doing so I will again quote an explanatory passage from Sir John Herschel's 'Outlines of Astronomy.' He says (page 149, third edition), "The weight of a body (considered as undiminished by centrifugal force) is the effect of the earth's attraction on it. This attraction, as Newton has demonstrated, consists not in a tendency of all matter to any one particular centre, but in a disposition of every particle in the universe to press towards, and, if not opposed, to approach to every other. The attraction of the earth, then, on a body placed on its surface, *is not a simple but a complex force, resulting in the separate attractions of all its parts.* Now it is evident that if the earth were a perfect sphere the attraction exerted by it on a body placed anywhere on its surface, whether at the Equator or at the pole, must be exactly alike, for the simple reason of the exact symmetry of the sphere in every direction." To produce this state of equilibrium in the sphere, it must be assumed that the mass of matter composing it is homogeneous, for it is evident that if the matter near the pole possessed more attractive power than the matter near the Equator, the attraction of a body placed anywhere on the surface could not be exactly alike. Now it is admitted that the equality of attractive power is disturbed by rotation. The centrifugal force at the Equator diminishes the attraction of gravitation or the weight of a body about $\frac{1}{300}$th part; whilst its influence gradually diminishes to nothing on approaching the poles. The matter at the Equator is thus rendered specifically lighter than the matter near the poles, and the mass of the sphere *ceases to be homogeneous.* The attraction exerted by it on a particle of matter placed anywhere on its surface (midway between the Equator and the pole, for example) would therefore be no longer exactly alike. The separate attractions tending to draw the particle towards the Equator would cease to be equal in force to the separate attractions in the contrary direction, which counterbalanced them when in a state of rest; and the attractions on the particle in the direction of the Equator being weakened, it would obey the superior forces urging it towards the pole.

For example, let M (Fig. 1) represent a particle on the surface of a homogeneous sphere drawn towards the mass by separate attractions in all directions, a few of which are represented by M*a*, M*d*, M*c*, M*e*, and M*b*. The force M*c*, which attracts the particle directly towards the centre *c*, is but a small part of the whole, but, so long as the other forces on every side of M*c* remained relatively equal, their combined actions would tend to draw the particle towards the centre. Thus, the force M*a* drawing the particle towards the Equator E, would be counterpoised by the equal force M*b* drawing it towards the pole P; in like manner, M*d* would counterbalance M*e*, and so on of all the other equal diagonal forces bearing on the particle from opposite sides. The result of those combined attractions would be to draw it towards *c*, and the sum of their forces would constitute the weight of the particle. But if the forces M*a*, M*d*, were to become less than the corresponding forces which tend to draw the particle towards the pole, the resulting direction of the combined forces acting on M would not then be towards the centre, but towards some other point on the axis nearer to P, and the weight of the particle would be diminished. That is the effect of rotation on a sphere of homogeneous matter: the attraction of gravitation in those parts near the Equator is diminished in a greater degree than in the parts nearer the pole, consequently the particle M would be urged towards the part by which it was most strongly attracted.

FIG. 1.



This effect of centrifugal force is the more manifest if it be considered as acting on a suspended plummet instead of on a body resting on the surface. In that case the insignificant effect of centrifugal force compared with the attraction of gravitation becomes more apparent, and the actual direction in which the combined forces attract the body may be viewed without being obscured by the ordinary notions of the action of centrifugal force when not counteracted by central attractions. Thus, when the sphere was at rest the plummet would be drawn by the separate attractions of all parts of the mass towards the centre with a given force, and the plumb-line would be perpendicular to the surface. But when the sphere was in rotation, the attraction of the plummet to the earth would be diminished by centrifugal force in proportion to the velocity of the rotation of the sphere at that part where it was placed; and the relative attractions of the sphere having been altered by the diminution of gravity at the Equator, the plummet would be drawn towards the pole, and the plumb-line would no longer be perpendicular to the surface.

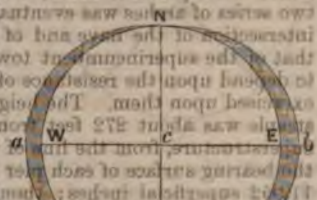
If the mass of matter were fluid, the effects of gravitation and of centrifugal force would be materially altered. The fluid when at rest would accumulate round a central point, and form a perfect sphere, each particle on the surface being at an equal distance from the centre, and each one would be stationary, for none would be attracted more strongly in one direction than in another. So long therefore as the fluid sphere remained at rest there would be equilibrium in every part; but that condition would be immediately changed if the sphere were rotating about an axis. In that case, the gravity of the fluid near the Equator being diminished by centrifugal force, the relatively increased attraction of the fluid matter near the poles would draw those parts of the sphere nearer together, and a quantity of the lighter fluid would be protruded at the Equator, until the quantity thus forced outwards compensated by its increased mass for its diminished density, and the equilibrium was by that means again restored. The attractions on all parts of the surface being thus rendered equal, the weight of the same body would be the same on every part. The figure of the fluid mass would be that of an oblate spheroid, of greater or less ellipticity according to the velocity of rotation, and it would be of such proportions that the plumb-line would be perpendicular to every part of the surface, for that is one of the conditions of equilibrium.

It must be especially observed that the formation of an oblate spheroid by the rotation of a fluid mass differs essentially from the ordinarily assumed formation of a solid spheroid by rotation. In the former case equilibrium is restored by the mutual attractions of the matter near the poles, and by the interior adjustment of the particles of the mass among themselves, not by transfer of particles along the surface; whereas, in a solid globe no such effects of mutual attraction and internal adjustment of parts could be produced.

A consideration of the effect of the separate attractions of different parts of the mass of a solid *spheroid* like the earth on a particle upon its surface strongly confirms my view of the action of centrifugal force, either when considered at rest or when rotating with various degrees of velocity.

It has been proved by the most eminent mathematicians that the attraction of gravitation on the surface of a spheroid of homogeneous matter *at rest* is greatest at its shortest diameter. Supposing therefore that matter were added to the opposite surfaces of a solid sphere, so as to shape it into such a spheroid as would be formed by the rotation of a fluid mass, a particle placed upon it when at rest would be attracted towards the parts where there was the least quantity of additional matter. Thus, let NWSE (Fig. 2) represent a section of a sphere, to which the matter W*a*E*b* had been added, so as to form the spheroid N*a*S*b*, of which NS is the shortest diameter. A particle placed anywhere on such a spheroid would be attracted towards N or S, and not, as might at first be supposed, towards the part where the greater quantity of matter was accumulated. This seeming paradox is caused by the mutual attractions of the added mass W*a* and E*b*: and the result of those attractions, combined with the attraction of the mass of the original sphere, is to draw any particle on the surface towards the centre *c*; and N and S being the nearest points to the centre, the force of attraction is stronger there than at any other part of the surface. It may be observed also that at N and S the separate attractions of the added mass act on the particle equally in all directions, and tend to draw it towards the centre. This effect of the additional mass of matter would be increased if its density were greater than that of the matter of the sphere; and, paradoxical as it may appear, the attraction to the poles would also be relatively increased if the density of the added mass were less than that of the sphere.

Fig. 2.



That the increase of density would increase the attraction at the poles will be readily conceived; and the contrary will be evident if the space W*a*E*b*, which forms the sphere into a spheroid, be supposed to be a hollow shell devoid of attractive matter. In the latter case a particle would be attracted even more strongly towards N or S than if the density of the protruded portion were increased, for though the absolute amount of attraction would be less, the relative difference would be greater. Thus it will appear, that by gradually diminishing the density of the protruded matter, a point might be attained on a spheroid at rest at which the attraction of gravitation at every part of the surface would be equal. This diminution of density would take place were the assumed spheroid put in rotation about its shorter diameter, and the velocity of rotation might be gradually increased until the spheroid was brought into the condition of equilibrium. But until that condition was attained a particle on the surface would continue to be drawn towards either pole, notwithstanding the direction of centrifugal force; and that is the condition of the earth at the present time. The centrifugal force would not counteract the original tendency of attraction towards the poles until it was sufficiently powerful to produce equilibrium, and then the particle would remain wherever it was placed.

Supposing the velocity of rotation were increased beyond the state of equilibrium, the continued diminution of the attractive power of the protruded mass would relatively increase the attraction towards the poles, and the particle would again tend to move in that direction. The velocity of rotation might indeed be so far increased as to bring the attractive power of the protruded portion of the spheroid into the condition before noticed of a hollow shell, when the relatively increased attractions of the poles would draw all movable surface matter towards them. Thus, whether a spheroid be considered at rest or in rotation, particles on its surface would be attracted towards its shorter diameter, excepting when the velocity of rotation was exactly sufficient to produce equilibrium.

The chief argument adduced and relied on by those who maintain that water on the surface of a solid rotating sphere would recede from the axis is, that the direction in which a particle is urged by centrifugal force, combined with the attraction to the centre of the sphere, would carry it towards the Equator. The distinguished mathematician to whom I have before referred as having opposed my views on this subject, favoured me by stating and by solving the problem in that way; and as it is a clear exposition of the objections to my hypothesis, I will give it in his own words:—

> "I suppose that you will admit that if a particle be constrained to move on a smooth surface, a force acting in a direction *perpendicular* to that surface will not impel the particle in any direction, but will be wholly counteracted by the pressure of the surface.
>
> Let now the figure (Fig. 3) represent a homogeneous globe revolving uniformly about an axis P*p*, passing through its centre *c*, and let M be a particle on the surface: in what direction will it be impelled? By introducing the so-called centrifugal force we may treat the problem as one of equilibrium, though the sphere is in reality in motion. The forces acting on M are, the attraction MA, in a direction towards *c*, and the centrifugal force MB, in a direction perpendicular to P*p*. Produce AM (Fig. 4), and let fall BD perpendicular to AM. The force MB may be replaced by its components MD, DB, along and perpendicular to AM. The former merely neutralises a portion of the force MA; the latter acts tangentially. Let ME (Fig. 5), acting towards E, represent the excess of the attraction over the perpendicular component MD, and let M*b* be drawn equal and parallel to DB, so as to represent the tangential component. The force ME, being perpendicular to the surface, will be wholly counteracted; the force M*b* will impel the particle *towards the Equator*. The increase or decrease of the force in passing from one point to another has nothing to do with the direction in which the particle is impelled, which depends only on what the force is where the particle is, not on what the force would become if the particle were to move into a position where at present it is not; and accordingly, not on what the force *would become* (or whether it would increase or decrease) if the particle were to move into such or such a position."

Fig. 3.

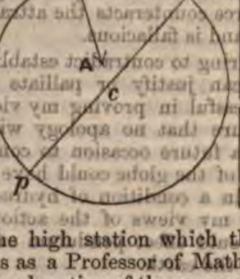
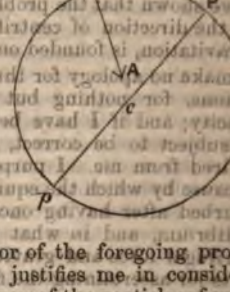
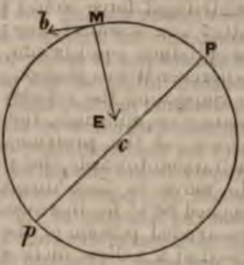


Fig. 4.



The high station which the author of the foregoing problem holds as a Professor of Mathematics justifies me in considering his explanation of the assumed tendency of the particles of matter on the surface of a rotating sphere to move towards the Equator as the one that is generally accepted; it is important therefore that I should examine the problem, and point out the erroneous assumptions on which its solution is founded. I admit that if the sphere when in rotation be regarded as a homogeneous mass, the attraction of gravitation would act on the particle M perpendicularly to the surface, and that the result of the composition of the two forces would be the attraction of the particle towards some point nearer the Equator than the centre of the sphere, and it would consequently be impelled from the pole. But it has been shown that the effect of centrifugal force is to disturb the homogeneity of the mass, and that the point of attraction would not be the centre of the sphere, but some part nearer the pole, and that the particle would therefore be attracted in that direction.

Fig. 5.



In the next place, the statement that the variation of attractive force at different parts of the surface has nothing to do with the direction in which the particle is impelled, is directly at variance with Newton's demonstration, "that the attraction of gravitation on a body placed on the surface of the earth consists not of a tendency of all matter to one particular centre, but is a complex force, resulting in the separate attractions of all its parts." The force acting on the particle at any point is the result of many forces acting on it in different directions, and if they increased or decreased in any of those directions, the action on the particle of matter would vary accordingly. Though it is true therefore that the direction in which a particle would be impelled "depends only on what the force is where the particle is," the direction and amount of the force would depend on its component parts; and, in the case of a particle on the surface of the earth, on the relative degrees and directions of the separate attractions of all its parts. I agree that the question is "not what the force *would become* if the particle were to move into such or such a position;" but I contend that the different forces in such and such a position influence the attraction of the particle where *it is*.

I might, if it were required, present several other considerations in support of my proposition, but I trust that what I have already said is sufficient. I have considered the question from various points of view, and each one shows that the tendency of the rotation of a solid globe is to attract matter to the poles and to repel it from the Equator. It has been shown, that if bodies on the surface of the earth obey the same law in relation to the earth itself that they do to one another, they must be attracted towards the poles, because those are the points of greatest attraction; it has been shown that, according to Sir John Herschel's illustration of the diminution of gravity at the Equator, bodies would be drawn towards the axis of the globe by the action of centrifugal force; it has been shown by an examination of the cause of the diminution of gravity at the Equator, that centrifugal force disturbs the homogeneity of the matter in the globe, and increases relatively the attraction of the mass near the poles; it has been shown that in a fluid mass the disturbance of equilibrium is compensated by the compression of the poles, and by the internal adjustment of the fluid particles, which is impossible in a solid sphere; it has been shown also that on a solid spheroid, whether at rest or in rotation, the points to which water would flow are the poles; and after having, as I conceive, established my position by arguments based on those facts and illustrations, I have shown that the problem by which it is attempted to prove that the direction of centrifugal force counteracts the attraction of gravitation, is founded on error, and is fallacious.

I make no apology for thus venturing to contradict established opinions, for nothing but truth can justify or palliate such audacity; and if I have been successful in proving my view of the subject to be correct, I am sure that no apology will be required from me. I purpose on a future occasion to consider the cause by which the equilibrium of the globe could have been disturbed after having once been in a condition of hydrostatic equilibrium, and in what manner my views of the actions of centrifugal force and gravitation would effect pendulum experiments for ascertaining the figure of the earth.

Hampstead, July 10, 1861.

ON THE OPERATIONS LATELY CARRIED ON AT BAYEUX AND CHICHESTER CATHEDRALS.*

By G. R. Burnell.

The preservation of the monuments connected with our civil or our religious history is a subject of so much importance, and it is one which appeals so strongly to the feelings of all who are connected in any manner with the architectural profession, that it would be useless here to enter into any explanation of the reasons for my venturing again to call your attention to the contemporary events I seek to place in parallel. A great national calamity has befallen us in the utter demolition of the beautiful spire of Chichester Cathedral: it seems to be apprehended by persons able to form correct opinions in such cases that the spire of Salisbury Cathedral is in a state nearly as dangerous as that of Chichester was about twelve months since; and some others of our most beautiful mediæval buildings are unquestionably in a very unsatisfactory condition. Under these circumstances it seemed, to me at least, very desirable that an attempt should be made to derive all the practical information it was possible to do from the lessons furnished: on the one hand by the sad accident which has befallen the works at Chichester; on the other, by the successful operations of the same nature executed at Bayeux. Possibly in this manner we may learn the nature of the danger now threatening Salisbury, and the best means of obviating it: at any rate, it is our duty to compare the technical processes adopted in the respective cases referred to, which have led to such markedly different results.

In the case of Chichester Cathedral, it would appear that the objects which the original promoters of the restoration proposed to themselves, and which served as the basis of the instructions given to the architect, were, to remove the existing choir fittings, and to open out the choir, in order to afford greater accommodation for the public at the cathedral services; and it was distinctly understood, as I have been informed, that the works so contemplated were not to include any structural repairs. The ancient stalls and the Arundel screen concealed to a considerable height the surfaces of the piers under the great arches of the steeple. The piers rose to a height of about 45 feet from the floor to the springing of the semicircular arches; the openings of the latter being respectively 25 ft. 8½ in. and 24 ft. 2 in. in the portion of the arches which was able to produce any dynamical action. Above the semicircular arches there were some pointed discharging arches of great strength, if we may judge by the published description of them; but as the weight supported by the two series of arches was eventually brought upon the piers at the intersection of the nave and of the transept, their stability, and that of the superincumbent tower and steeple, was in fact made to depend upon the resistance of those piers to the various efforts exercised upon them. The height of the extreme portion of the steeple was about 272 feet from the ground; the weight of the superstructure, from the line of the capitals, was about 5664 tons; the bearing surface of each pier is stated to have been 83 feet, or 11,952 superficial inches; though, from some dimensions 1 obtained in the cathedral itself, I suspect that the available bearing surface was not much more than 74 feet, or 10,656 superficial inches; or in round numbers, the crushing weight at the springing line might have varied between nearly 264 and 300 lb. per superficial inch, acting upon an irregular rectangular pillar, whose height did not exceed nine times the dimensions of the smaller side; and it is to be observed that the longer axes of the piers corresponded with the centre line of the wider openings, and to some extent with the line of the action of the prevailing wind, thus offering the greatest external action to produce overthrow.

The piers of the tower (as hereafter I propose to call the piers at the intersection of the nave and transept, immediately under the tower and spire,) were portions of the early part of the cathedral; and they were constructed, as we can now too plainly perceive, in the very worst possible manner. They were formed of a species of ashlar casing composed mainly of a tertiary shell-limestone from the Isle of Wight, with, from here to there, stones obtained from other quarries; and the interior was filled in with concrete, apparently made of chalk-lime mortar, and broken stones and flint. Now, the Isle of Wight stone itself is said only to be able to support a crushing weight of from 466 to 566 lb. per superficial inch, when used in the direction of the bed; although I am myself far from admitting the correctness of the experiments on which this statement was made. Yet as the sectional area of the ashlar coating was not more than one quarter of the whole area of the piers, and the mortar of the interior was so badly made as to offer hardly any resistance—nay, rather to act in such wise as to tend to burst the outer casing, and at any rate to fatigue rather than to assist the ashlar—the wonder really is, that the piers should have supported for so many years, as they actually have done, the weight thrown upon them. It is evident, indeed, even now, that some very serious settlements must have taken place in these piers, and in the arches over them, at a very early period in the history of Chichester Cathedral; for on the eastern wall of the transept it is easy to discover that, when the south-eastern part of the transept was built, the horizontal courses over the arches of the aisle had been deranged by the subsidence of the great piers, and that they had sunk to such an extent in the immediate neighbourhood of the piers as to require the introduction of a feather-edged course to bring the masonry to a level line. Some distinctly-marked ancient movements may likewise be traced to have existed in the various arches still standing in this part of the cathedral, all of which are of a remote date; but little attention seems latterly to have been paid to them, because they had not increased of late years, and because the parts of the piers which displayed the effects produced upon them were hidden by the woodwork of the stalls, and by the Arundel shrine. On the recent demolition of the last-named accessory details (the stalls and shrine), the defects of the tower supports were laid bare. Large fissures were found to exist in the piers, and in the south-west one it was found that a large portion of the ashlar casing had actually been cut away to receive the Arundel shrine: the nave arches had likewise been distinctly fractured, in consequence of the subsidence of the piers. From all that I could observe, I feel convinced that this subsidence had arisen from the compression of the masonry of the piers themselves, and not from any compression of the foundations. A state of equilibrium had however been attained; and though it might at any moment have been disturbed had any new forces been brought to bear on the building, yet that equilibrium might in all probability have lasted for centuries if the works for the removal of the screen and stalls had not been undertaken. The vibration of the steeple has been dwelt upon as a cause of the failure of the tower piers to a much greater extent than I think was justified. It is more than probable that at the precise moment of rupture the effect of the wind may have caused a movement which precipitated the fall; but the steeple had for centuries been exposed to and had resisted the effects of gales more severe than the one which is considered to have produced the catastrophe we so much deplore; and even in the early spring of last year (1860) the steeple had been exposed to a gale exercising a horizontal effect more than double that of the gale of 21st February last. The immediate cause of the fall of Chichester spire must, then, I think, be sought for in the operations lately carried on for the repair of the tower piers.

---

* Read at the Royal Institute of British Architects.

The various instances quoted by Prof. Willis of the fall of other steeples, and the accidents which have lately occurred to some of the great engineering works of the age, might have induced the parties entrusted with the maintenance of Chichester Cathedral to suspect that there was danger in disturbing any portion of structures so badly built as nearly all mediæval buildings notoriously are. I cannot, therefore, for my own part, refrain from expressing my regret that the committee of 1859 should have adopted as their ruling principle "that the accommodation in the cathedral was alone to be attended to, and that no structural works were to be undertaken." The limited instructions given to the architect under this arrangement compelled him to seek for temporary palliations for any evils he might discover in the course of removing the old works; and were, in fact, his justification for attempting to recase the fissured piers, rather than at once undertaking their re-construction. Still, when a building has stood apparently unmoved for centuries, it is difficult to believe that a few slight jars, or the removal of some accessory fittings which seem to have only a slight connection with the substantial parts of the structure, would be able to destroy that which had lasted so long; and architects and engineers of the present day who are accustomed to build so strongly as to defy even exaggerated efforts, are too often unaware of the risk they run in dealing with the works of the mediæval architects, who were, as a general rule, very ignorant of the scientific part of their profession, so far as the use of building materials was concerned. The fatal, though easily justifiable oversight made at Chichester, seems to have consisted in the belief that the interior of the piers of the tower was able to support any notable portion of the superincumbent weight whilst the exterior coating was being repaired. From the state of the ruins, and the nature of the phenomena which attended the fall of the steeple, it seems to me evident, as I said before, that the concrete filling of the piers had been originally executed with chalk-lime mortar, badly prepared, and placed in contact with materials which were able to abstract from it the water necessary for the crystallisation of its hydrate of lime. It is said that shortly before the fall of the spire, dry mortar dust, as workmen would say, poured occasionally from the fissures: thus proving that the hearting of the piers only consisted, in fact, of an incoherent mass of dry rubbish, able to flow over itself in the manner of dry sand. It would have been possible to have ascertained whether or not this had actually been the case, before the repairs had gone to any great extent, simply by boring into the columns in several places in their heights; and some additional strength might have been given to the hearting by injecting liquid cement mortar through the bore-holes themselves, if the interior had been found to be tolerably sound. As it happens, any such measure would have been utterly useless; and, speaking as I now do from the vantage-ground of *ex post facto* knowledge, it is evident to me that the proper course to have been taken, directly it was discovered that "the tower piers were worse than had at first appeared," was at once to have removed them, and to have rebuilt them in sound ashlar work. *A fortiori*, was it necessary to have needled and centred the tower, and the adjacent arches, when the fresh movements declared themselves in November last? If vigorous measures had then been adopted, it would have been possible to have saved the steeple; in January, when "it was determined to add centres in all the arches," there was still time enough to prevent the fall; in February, it was too late to do any good, and the building must have been condemned, even had no gale occurred on the 21st of February.

The story of the repairs of Bayeux Cathedral is strikingly like this story of Chichester, though the measures adopted, and the results obtained, were so different in the two cases. Settlements had taken place in the masonry of the tower piers of Bayeux some centuries ago; recent repairs and alterations in the fittings had laid bare the marks of these movements, and had disturbed the condition of equilibrium into which the materials of the piers had subsided, so that at Bayeux, as at Chichester, the old movements were resumed; the materials forming the piers themselves began to yield unequally in the section of the piers; but, at Bayeux, the hearting was sounder than the external casing, and it was the latter therefore which gave the first symptoms of immediate danger. The architects consulted in this case seem at once to have perceived the magnitude of the threatened evil, and there was a unanimous conviction amongst them that the only course to be adopted was at once to rebuild the piers. Differences of opinion, however, arose as to the manner of effecting this object. The diocesan architect, and M. Viollet le Duc, thought that the simplest and cheapest plan was to pull down and rebuild the tower from its very foundations; others thought that the original structure might be saved by judiciously-executed underpinning; and M. Flachat—whom some people would call merely a railway engineer—had sufficient influence to persuade the public authorities to adopt that opinion. M. Flachat then was employed to execute the work of reconsolidation, and he succeeded in effecting it, in the manner and under the circumstances recorded in the very remarkable book lately published by his assistants, Messrs. Dion and Lasvignes. Bayeux Cathedral still stands, with the original work of its square tower and octagon lantern intact; and, according to all probability, it will continue to do so for centuries to come. So efficiently have the recent repairs been executed, in fact, that if this glorious structure should again be menaced with ruin, we may confidently predict that the tower will be exempt from the danger, and that its substructure will bid defiance to the ravages of time, so long at least as the stone used for the pillars is protected from the action of frost. I introduce the latter observation designedly, and shall have occasion hereafter to recur to it.

M. Flachat, in this case, commenced his operations (which perhaps I ought to say were only commenced after some injudicious works had been attempted by the local architect of the cathedral) by forming an artificial incompressible foundation of concrete, upon which subsequently he erected his centres and needles. The concrete itself was supported on twenty tubes (of wrought-iron, and of 4 feet internal diameter), subsequently filled with concrete, and sunk through the earth in such a manner as not to produce any vibration under the pillars; and round these tubes a general platform of concrete, rather more than 9 feet in total thickness, was inserted between the foundation of the piers. The tubes rose about 3 feet into the concrete, and were carried down to one of the stiff blue clays of the lower oolitic formations, into which they penetrated about 2 feet. Upon the concrete bed, M. Flachat then erected a double set of frames of whole timbers, on either side of the centres originally placed to support the arch, for the purpose of forming the seating of a set of needles carried upon a series of screw-jacks, and made to support the masonry of the square part of the tower, a little above the vaulting of the nave and transept. The tower was carefully hooped with iron-bars, keyed up whilst they were still hot, so that their shinkage actually closed the masonry which had previously been fissured over the openings; and before altering the centres to the form M. Flachat thought requisite, he also surrounded the springings of the arches of the nave with a strong wrought-iron cradle, intended to resist the lateral thrust. The centres were then strengthened and modified, so as to allow the easy underpinning of the piers; and the lateral arches of the nave, choir, and transepts, which had participated in the movements of the piers of the towers, were carefully shored up. Every precaution was taken to protect the original mouldings of the vaulting, and the sculpture of the capitals, columns, and bases, by inclosing them with rubble masonry, against which the shores were made to act directly. It is to be observed that the needling was totally independent of the centres of the great arches, and was designed solely to support the weight of the tower and octagon above the line of vaulting; the arches and the spandrel fillings were all that bore directly upon the centres themselves.

I must refer you to the book before mentioned for the detailed accounts of the centres, of the calculations on which they were designed, and of the precautions observed in placing them, in making good the old and the new work, and finally in the delicate operation of removing the scaffolding, centres, and needles. I do this with the more earnestness, because I am convinced that the architectural student who might study the various questions incidentally raised with respect to the dynamical efforts exercised, to the strength of the various materials employed, and to the mechanical powers brought to bear upon the work, would rise from such study with a truer view of the importance of the scientific part of his professional education than would appear to prevail at the present day. In fact, and at the risk of raising an issue somewhat irrelevant to the subject before us, I hold that a properly-qualified architect ought to be a scientific engineer, and that a good engineer ought to be equally an educated architect; or, in other words, that the modern distinction between the two branches of our profession is a very unnecessary one. In works such as the repairs of the piers of the towers of Chichester or of Bayeux cathedrals, the scientific part of the architect's duties prevails in importance over the artistic part; and I know no better authority upon the subject than the book in question. In our own language I am not aware that any work can be cited in which the operations for the underpinning of a lofty tower have been so elaborately described as they have been by Messrs. Dion and Lasvignes, who have moreover had the advantage of personally superintending the works they have so well described.

One very important remark remains to be made upon the general subject of the repairs of buildings, so seriously affected as were both Bayeux and Chichester cathedrals. It is this—that the cost of the works executed by M. Flachat for the maintenance of the tower and octagonal lantern of Bayeux was not less than £32,220; and that M. Viollet le Duc had estimated that the demolition and the reconstruction of the same works could have been effected for a considerably smaller sum. I am somewhat sceptical, I must confess, as to the correctness of M. Viollet le Duc's estimate in this latter case; and the amount of Mr. Scott's estimate for the repairs of Chichester Cathedral confirms me in this opinion, even after making all possible allowances for the prices of labour and materials in the two countries, for the local conditions, and the peculiar characteristics of the two buildings. Be this as it may, it is proved that the cost of underpinning a structure of about 6000 tons weight (in round numbers the weight of the upper part of Chichester tower and steeple was 5664 tons; that of the tower at Bayeux was 3700 tons) at a height of about 50 feet from the ground must have greatly exceeded £32,000. Candidly, I do not believe that previously to the execution of the works at Bayeux, or to the fall of Chichester tower, any architect who had been bold and honest enough to have said that such a work was necessary would have even been listened to. Still more firmly am I convinced that no committee whatever would, in our commercial country and in our industrial age, have succeeded in raising the funds for carrying such a work into effect. The committee for the repairs of Chichester Cathedral were then, I think most sincerely, perfectly justified in confining their attention to the improvement and alteration of the internal fittings, and, for the time, in avoiding to entertain the consideration of structural defects. The manner in which the partial repairs actually attempted were executed, was unfortunately one which revived the injurious actions previously observable in the building, and which had remained, as it were, quiescent for so many years. But the limits of resistance of the piers must have been so nearly attained when the slight jars produced during their recasing, and the trifling alterations in the conditions of equilibrium produced by the removal of the stalls and of the Arundel screen, could determine the crushing of those piers, that a cup so full might at any time have run over: or, in plainer words, any gale of wind able to produce a long series of isochronous vibrations in the steeple might have produced the same effect, and caused the piers to crush under their action. I am firmly persuaded also that no architect or engineer but one who had been practically acquainted with the wretched style of building adopted by the mediæval builders, and who had witnessed the failure of modern lofty structures, could have suspected before the fall of Chichester spire the truly awful state of the masonry of the piers on which it rested. There was hardly enough energy displayed in the attempts made to arrest the fall when the imminence of the danger made itself felt; but apart from the regret all true lovers of archæology must feel at the loss of the original monument, and at the substitution in its stead of a modern copy, it is to my mind questionable whether, in the end, the pecuniary cost of rebuilding the steeple, as must now forcedly be done, would much exceed the cost of underpinning and replacing the original piers and arches. Without being optimists, or holding the extreme doctrine that "whatever is is right," it should be to us a source of comfort to know that the actual amount of injury produced to one of the most beautiful monuments of the ecclesiastical history of our country has not been greater than the destruction of the steeple and the adjoining bays of the nave, choir, and aisles; and that in common prudence the parties intrusted with the care and preservation of the building could hardly have adopted a different course from the one they have actually followed. That so serious an accident as the fall of this spire should have occurred without injury to life or limb is, I would add, highly creditable to the clerk of the works and to the builder employed.

Before closing these remarks, I would beg to call your attention to one or two practical questions connected with the nature of the materials employed at Chichester and at Bayeux. On the occasion of the discussion on the paper read by Prof. Willis before this Institute, Mr. A. Thompson dwelt upon the small powers of resistance of the tertiary shell limestone from the Isle of Wight, which had been used in the construction of the piers. He stated that, when loaded transversely to its bed, this material only resisted a load of about 446 lb. per superficial inch; but when loaded in a direction parallel to the bed it was capable of supporting a load of 860 to 1070 lb. per superficial inch. Mr. Thompson also calculated that the actual load on the superficial inch on the cross section of the piers was not less than 331 lb., or rather more than my own rough calculation had indicated. Mr. Thompson did not state whether the breaking weights he quoted were the instantaneous or the ultimate breaking weights of the stone; and I mention this omission because it is one which materially affects the value of the information given. Vicat has shown that stones will frequently yield, after three months, under loads which do not exceed one-third of the breaking weight applied instantaneously; and as irregularities in the texture of stones are very common, it is fair to assume that the safety load they ought to be made to bear should never approach even the lower limit. Mr. Thompson stated that the stone had been used bedwise, and therefore in its weakest direction. If so, I cannot but suspect that some error has crept into his observations, for I am sure that a stone which would crush under a load of 446 lb. would not support for centuries a load of 331 lb. As to the hearting of the pier, if it had been executed in good chalk-lime brickwork it might have carried a load of about 500 lb. on the square inch, had every imaginable precaution been taken in its execution,—executed as it was in bad rubble, or rather in bad concrete, it could not have supported even its own share of the work, or a load of 331 lb. Under these circumstances the outer casing must have borne a load far in excess even of the 331 lb. calculated by Mr. Thompson; and they go far to convince me that the safety limits of the shell limestone must be higher than Mr. Thompson's experiments would appear at present to indicate.

Unfortunately we do not possess any tables of the resistance of English building stones to crushing weights which can be considered to be perfectly satisfactory. All the experiments recorded, excepting the few mentioned in Mr. E. Clark's account of the Menai Tubular Bridge, have been made upon small cubes of at most 2 inches on the side. In practice however the resistances are singularly modified by the joints, and the interposition of mortar between the bearing surfaces; whilst Vicat's experiments upon small superposed cubes seem to indicate that the number of such horizontal joints considerably modifies the resistance of each of the cubes. Again, the results usually quoted of late years of the resistances of building materials have been obtained by the use of the hydraulic press, an instrument which is very likely to get out of order, and whose indications cannot easily be watched with the accuracy required in investigations of this delicate nature. Mr. Hodgkinson in his experiments on iron, wood, and some kinds of stone, and M. Flachat in his observations upon the resistances of the Aubigny, Orival, Caen, and Ranville oolites, used a system of levers in the applications of the weights to those materials; and though unquestionably there is a probability of the weights being in such cases made to bear unequally upon the exposed surfaces, the danger is not greater than when the hydraulic press is used, while on the other hand it is far easier to apply the load by slight increments, and to watch its action during even a lengthened period. After all, the most valuable observations upon the resistance of building materials are those to be obtained from observation of the conditions of success and failure of actual constructions, such as Rondelet records in his 'Traité de l'Art de Bâtir.'

I said that I would refer to the selection by M. Flachat of the Aubigny stone for the ashlar of his new piers; and I do so because I observe that this stone is being employed rather extensively in London, and because I am convinced that its use would be attended with danger. M. Flachat chose this stone because it yielded more satisfactory results under the trials he exposed the various local stones to, so far as their resistances to crushing weights were concerned; but Messrs. Dion and Lasvignes expressly state that the Aubigny stone yielded easily under the action of frost, if used exteriorly. Anyone who may have examined the mediæval buildings in the town of Falaise must also be convinced that the opinion last quoted is lamentably correct; for the Aubigny stone used there has decayed in a frightful manner. I am however disposed to believe that even when used in the interior of a building the Aubigny stone is exposed "to take on" a decay somewhat analogous to the mysterious decay which we know affects the Purbeck and Petworth marbles in our own cathedrals; and though the sectional area of the piers at Bayeux is so great as to remove any fear of the decay of the outer surface affecting the stability of the structure. yet I fear that the edges of the various courses will ultimately crumble away, like those of the Purbeck marble, and produce an unpleasant series of horizontal lines upon the piers. It may be centuries before this effect is produced; but I confess that, knowing what I do of the Aubigny stone, I regret to see it used in a building destined, I hope, to exist, "not for an age, but for all time."

Finally, some importance seems to have been attached by the persons who were charged with the superintendence of the recent operations for the repair of Chichester Cathedral to the use of blue lias lime in conjunction with the stone casing applied to the piers. In this case I think the use of that cementing material was a mistake—of a minor character, it is true, because whatever lime or cement had been used was a matter of absolute indifference, and would in nowise have prevented the fall of the steeple. In all future operations of the same kind however, to be executed elsewhere, it seems to me that we may learn a useful lesson from what thus occurred at Chichester. Evidently, the rapidity of setting and the hardness of the set mortar are the most essential conditions to be required of those materials in works of restoration; and therefore I hold that the new casing ought to have been set in Portland cement, rather than in blue lias lime mortar. M. Flachat used large quantities of Portland cement in setting the large ashlar blocks he used in the piers of Bayeux: *à fortiori*, a cement of equal energy should have been used in setting the thin casing applied at Chichester. In addition to this consideration, there is another practical objection to the use of blue lias lime in the south-east of England, in the fact that there are so few masons, or even bricklayers, who know how to use it; and I am strongly of opinion, from what I actually witnessed in the ruins of Chichester Cathedral, that the blue lias lime there employed had never been properly slacked—its hydration was deficient in many samples.

The fall of Chichester Cathedral, and the danger said to menace the glorious spire of Salisbury, raise one singular subject of discussion which may fairly be submitted to this Institute, which boasts for one of its objects the advancement of the true interests of architectural education, and, I hold, by implication of the preservation of the best models of architecture. It is this —whether it be not desirable that some organisation analagous to the one which prevails amongst our neighbours, for the preservation of the monuments connected with the history of the country should be introduced in England. The central government of France contributed not less than £28,000 out of the £33,000 (nearly) spent at Bayeux. The repairs of Notre Dame at Paris will eventually cost the state no less than £360,000; and as the ancient buildings of a country are in fact a portion of the intellectual property of the whole nation alike, it does seem to me that their maintenance should not be left to local or casual efforts. No doubt, the absorption of the ecclesiastical and capitular revenues of the French churches by the governments subsequent to 1789 has placed the ecclesiastical affairs of that country on a different footing to those of England. Nevertheless, I cannot conclude without expressing the regret that the attempts now being made to complete the restoration of a monument so closely connected with English history as Chichester Cathedral should depend for their success on the results of a public subscription. At present it would of course be in vain to expect any assistance from the state, and our efforts must be confined to assisting the subscription list. This may be done with the more confidence that Mr. G. Gilbert Scott has been intrusted with the execution of the future works,—a fact which insures that everything which science, skill, and taste can bring to bear upon them will be applied.

In the *discussion* which followed—

Mr. Gilbert Scott, R.A., said, that in offering some observations on the paper just read, it was not his intention to go into the history of the gradual failure and catastrophe of the tower of Chichester Cathedral, but to refer to the rebuilding. Mr. Slater was the architect of the Dean and Chapter; but, as the public had come forward and assisted the fund by their subscriptions, he (Mr. Scott) had been asked to act in the interests of the latter: and he and Mr. Slater were acting conjointly in supervising the rebuilding. He thought it necessary to mention this circumstance, as whatever had come to his knowledge of the previous occurrences had been picked up accidentally. It was, he thought, most important, inasmuch as the country was studded throughout its length and breadth with beautiful specimens of Mediæval architecture, the restoration of some of which might possibly be confided to their hands, that as architects they should consider what were the means which ought to be adopted, and what the considerations to which they should give their attention with reference to these buildings. And here he was bound to say, that Mr. Slater had been peculiarly unfortunate under the circumstances in which the works at Chichester Cathedral had come into his hands. If he had been called upon by the Dean and Chapter to report on the condition of the cathedral tower, the case would have been quite different, as under such circumstances his attention would have been devoted to that particular point, and he would have taken steps to avert the calamity; but he was not so called upon. He was called in, and told that he was to make a new arrangement of the seats in the choir, so that more room might be given to the worshippers; but he was not to turn his attention to reconstruction, because, as a matter of fact, there were no funds for the purpose in the hands of the Dean and Chapter. A committee was formed to re-arrange the interior as a memorial to the late Dean Chantry, and there were no funds disposable for any other purpose. The state of the tower was only brought under notice accidentally, and bit by bit, while the other operations were going on. It might be that under such circumstances an architect might discover the mischief, though his attention had not been specially called to it; but if his instructions were merely to arrange the seats in the choir, he was not bound by any professional responsibility to go into the question of reconstructing the tower. This was a matter which ought not to be lost sight of in considering the degree and nature of the responsibility attaching to the architect of Chichester Cathedral. It was however discovered, in the course of the re-arrangements to which he had referred, that some serious mutilations had been committed in reference to the piers which supported the tower. With respect to this tower, as compared with that at Bayeux, he thought that they ought not to indulge in any invidious comparisons between railway engineers and architects; because at Bayeux a railway engineer had been successful, while at Chichester a railway engineer had also been called in with an opposite effect. Some time ago, a railway engineer was called in to advise with Mr. Slater, and he made three reports, and a fourth supplemental one; and there was nothing in any of them to tend to any different or more decided course than that which had been adopted by Mr. Slater. The last report was made after the latter gentleman had operated on one of the towers, and it stated that the work had been done in a most masterly manner. At an early period in his practice he had been called upon to inspect the Church of St. Mary, at Stafford. He found that all the piers were crushing, and that although from time to time attempts had been made to arrest the decay, they had in course of time given way. After he had made the specification for shoring up, two tenders were sent in for that portion of the work, and both were by very respectable men. One was for £1500, and the other for £500. He thought that it would not be fair to bind the person who named the latter sum to do it for that amount, as he felt persuaded that it could not be done; so the contractor did other work in the church, and was paid for the shoring by day-work, and it was found to cost £2000. The course which he (Mr. Scott) adopted with reference to St. Mary's, Stafford, was that which was generally adopted, except at Bayeux. What they did was to go gradually round the surface, and insert good stone, until they thought they had almost rebuilt the pier. The restoration at Bayeux was, on the contrary, a case of perfect rebuilding; for, as he understood Mr. Burnell, the old work was entirely removed, and the new piers built in from the foundations. At Stafford, the first thing they did was to tie round the tower with iron bands, with screws right and left, so as to make them as tight as possible. They then dug round the base of the tower, filling up the cavity, graves and all—the latter often the cause of much mischief—with concrete. Having shored up the arches, so as to carry as much as possible of the superincumbent weight, they began gradually to remove the loose ashlar, and to put in new foundations, fixing other temporary shores, until they had finished the entire pier. In effecting this operation he was brought to the conclusion that it was impossible to exaggerate the danger and difficulty that existed in providing shoring of sufficient strength; for in every work of the kind on which he had been engaged, he invariably found that all the shoring he could by any possibility get in was barely sufficient for the purpose. He had seen enormous timbers give way before the tremendous pressure to which they were subjected; and therefore his advice was, that before the ashlar was touched it was absolutely necessary to put up all the shoring that could be brought to bear within the space to be operated upon. In the estimates which he had prepared for Stafford, he provided for the use of whole timber; but the clerk of the works had permitted half timber to be used, and the consequence was that the tower gave way very perceptibly. Another precaution which he recommended was, that the hardest possible stone should be used, and that under no circumstances should anything approaching to a soft stone be substituted. The next thing to observe was, to avoid mortar, and always use cement instead. The plan which was adopted was to pour in water first, and then liquid cement, which he had observed to run down the rubble to the depth of 9 or 10 feet, as if it were so much quicksilver. The next work of the kind on which he was engaged was at St. Mary's, Nottingham, where the piers were smaller and higher, but the weight greater, and the operation more difficult, owing to the smallness of the piers. The works were conducted under the inspection of a very clever clerk of the works, who had given him a complete history of the operation. Here, as at Stafford, he put in ties, or chambers of iron or copper, in every course, to bind the work. At Aylesbury, where he undertook a somewhat similar operation, he was obliged to reconstruct the foundations; and then he found that, strong as the shoring was, it showed signs of giving way. This was, at all events, to some extent satisfactory; because it prevented an employer from saying afterwards that too much money had been thrown away on timber. While engaged on the works at Stafford, a tremendous report, like the noise of a cannon, was heard; and it was found that one of the piers had split up from top to bottom. At Aylesbury they wanted a long shore, and they procured one 2 ft. 6 in. square, one of the largest he had ever seen, and yet it was actually bent by the enormous pressure upon it. With regard to the reconstruction at Bayeux, the work was no doubt carried out in the most masterly manner, and the subject was one which every architect would do well to study. The architect at Bayeux had not gone round the casing bit by bit, but had made new foundations and new piers; and he (Mr. Scott) confessed that he was astonished that such a system of shoring as that used had proved sufficient for the purpose. The process seemed to have been, to have "needled" it just over the arches, an operation which he should have thought would not have been sufficient to bear the weight of the tower. When the architect had to deal with buildings of the scale of cathedrals, the difficulties became increased, for timbers were after all of limited size, and it became necessary to build ports, as at Bayeux. The manner of sinking the foundations by means of wells, or cast-iron pillars, was, he thought, a most admirable contrivance.

Mr. Slater observed, that he had very little to say, after what Mr. Gilbert Scott had said so kindly for him. With regard to Chichester Cathedral, all he could say was, that he was placed in a most critical position, and that he had endeavoured to do his duty to the best of his ability. The commission which he had received from the Dean and Chapter was, to prepare plans for the restoration of the choir only, and not for structural repairs. There were, in fact, no funds for the purpose; and it was understood that his attention was not to be called to that part of the work. When however the defects of the tower became apparent, he did all that he possibly could to avert the catastrophe that subsequently occurred. They were not successful; but everything that could be done was done. He might state that the work of restoring Sherborne Minster had been carried out in the office in which he had learned his profession; and that in that case two piers were taken down and rebuilt, while the other two were found to be perfectly sound. There they had sandstone to deal with, but at Chichester there was nothing but a mass of rubbish.

Mr. Burnell, referring to the condition in which the piers at Bayeux were found, said that the "hearting" of the piece (which was part of the Norman cathedral) was more sound than the casing which had been put round it subsequently. At Chichester, on the contrary, the hearting was rubbish, while the casing was good. In both instances it was necessary to underpin or take the piers away.

Mr. Hills said he had visited the cathedral ten months ago, and had observed the manner in which the piers had been mutilated, as spoken to by Mr. Scott. Immediately above the back of the stalls he had observed a place where a part of the south-west pier was broken away and bound up with an iron strap; and his opinion then was, that it was impossible to ascertain the true state of the piers without removing the shrine. He did not see the building again until some months had elapsed; and late in the month of February last, when he paid it another visit, he remarked a crack in the north-west pier, which he was informed had been about three months in arriving at the stage in which he found it; and it was then about an eighth or a sixteenth of an inch in width. His own opinion was that the piers had commenced crushing long before, as they had many marks of ancient failures about them. The feather-edge course, referred to by Mr. Burnell, had sunk 4 or 5 inches; so that the probability was that in former ages there had been a great failure in the foundations. With regard to the vibration of the spire, he fancied that a good deal of exaggeration existed on that subject. He had repeatedly gone up the spire as high as it was possible to go, in all weathers, and he had never discovered any vibration whatever. The effect of the swing-gallery fixed by Sir Christopher Wren was also, in his opinion, much exaggerated; neither was it at all so heavy as was supposed. He was at the top of the spire (or as far as he could reach) on the Friday before it fell, and he was unable to detect the slightest vibration; neither had he perceived that the swinging-gallery was out of the perpendicular. Under these circumstances, it appeared to him perfectly clear that the spire was in a much better state than the tower, and that it had not yielded at all in proportion to what had gone on below. The stone used in the construction of the tower was very well known in that part of the country; and on the whole he thought it was a good stone. It had been extensively used in the oldest portion of the cathedral. It was similiar to that used at Winchester, and the abbey on the Isle of Wight. With regard to his (Mr. Hill's) own connection with Chichester Cathedral, he had reported, as requested, to Mr. Slater; and on that gentleman had devolved the responsibility of what had been done. The steps which it was proposed to take to avert the catastrophe were commenced on the Friday before the tower fell, and they were not dissimilar to those so successfully adopted at Bayeux. In fact, Mr. Slater had Bayeux in his mind at the time, and did all he could to obtain information of what had been done there. The first thing done at Winchester was to "jacket" the piers, in order to prevent them from bulging out, and that operation was only just commenced when the catastrophe occurred. A good deal of temporary shoring had been put up, but the signal which warned them to remove the workmen from the building was the circumstance that four of the shores began to bend in a very serious manner. One of them commenced to bend the night before the fall. They then tried to strengthen it by bolting it and another piece of timber together. Strong planks were used for this purpose; but before the second piece could be applied, the bend had so much increased (to the extent of a foot nearly), that it was found impossible to get the bolt through it. The remaining shores (three in number) also bent to the same extent, which showed that it would not be safe to go on any longer.

Mr. Digby Wyatt said, the description given of the means taken to rebuild the piers at Bayeux had suggested to him to inquire into the relative economy of the operation. In that case the architect had not availed himself of any of the strength remaining in the structure; but by erecting the peculiar framework described by Mr. Burnell, had removed all the piers at the same time. The operation must, he thought, have been attended with very great expense. In this respect he considered that our own English mode of proceeding, as illustrated by Mr. Scott at Stafford and Nottingham, was creditable to the country, for it was a sensible and prudent plan, and by no means wasteful in a pecuniary sense. It appeared that the foundations at Bayeux cost £2000, and they were, he thought, the best part of the work; while the rebuilding of the piers had cost £15,000. He thought, from what they had heard from Mr. Scott and Mr. Hills on the subject of shoring, that timber was not a good material; and he fancied that if cast-iron had been used at Bayeux, greater economy would have attended the operation.

Mr. Tite, M.P., observed that, with reference to his own experience, one case only had come within it; and that was the tower of a church in Essex, one leg of which had become bad. The churchwardens wanted to pull down the whole church; but he begged to be allowed to experiment upon it, and was permitted, and succeeded. On that occasion he used 4-inch wrought-iron bars instead of timber shores, which he found to answer very well, and to take up much less room.

◆

STEAM HAMMER FOR LIGHT FORGINGS.*

By Richard Peacock.

(*With an Engraving.*)

Power hammers are almost indispensable for the production of sound smith's forgings, and their extensive introduction into the smithery has been attended with most valuable results. Their application is not of recent date, but the extraordinary demand for forged ironwork for steamboat and railway work, has given an impetus to their use; and their adaptation to the more general wants of the smith's shop is marked by great advantage as regards both efficiency and expedition.

The Steam Hammer represented is now in use at the author's works, Gorton Foundry, Manchester; and is brought under notice by request, as an example of a practical and useful steam hammer for light forgings, heavy smith's work, stamping, &c. This hammer is worked by hand, and is either single or double acting: that is, that it can either be used by steam and allowed to fall by gravity alone; or, after it has been lifted, steam can be used above the piston to give increased effect to the blow. Fig. 1 is a vertical section of the hammer, and Fig. 2 a side elevation; Fig. 3 is a sectional plan through the steam cylinder and valve chest, to a larger scale.

The steam cylinder A, Fig. 1, is 10 inches diameter, and constructed for a 24-inch stroke. The valve B is cylindrical, turned to fit well in the valve chest, but to move easily within it. The top end of the valve is made longer on one side than on the other, as shown in Fig. 1, and enlarged to double the size in Figs. 4 and 8; and when the valve is in the position shown in the plan, Fig. 7, stean is admitted over the piston in the down-stroke, as in Fig. 6; but by turning the valve half round by the handle C, as shown in Fig. 3, the additional lap prevents the admission of steam above the piston, as in Fig. 10, and allows the hammer to fall by gravity alone. Figs. 4 to 6 show the top, middle, and bottom positions of the valve when turned for admitting steam above the piston in the down-stroke; and Figs. 8 to 10 show the same position when the valve is turned half round to exclude the steam from the top of the piston. The valve is worked up and down by the hand-lever D, Fig. 2; it is open through the centre, and the weight of the valve, valve-rod, and hand-lever, is counterbalanced by the spiral spring E. To prevent the piston from rising too high in the cylinder, a trigger F, Fig. 1, is fixed on the side frame, which, when struck by the roller G, on the hammer-block H, lowers the valve and allows the steam to escape from beneath the piston.

The piston is secured to the rod in the usual way by a cone and nut. The bottom end of the rod has a solid head I, seen in the section Fig. 11, and in the plan Fig. 12, of the hammer-block H, to which it is secured; this head is rounded on the top and bottom, and is made ¼-inch less in diameter than the hole in the hammer-block, to allow of any twist or vibration, in order to prevent the breaking of the piston-rod, which from the oblique strains due to the varied character of the forgings has hitherto given great trouble in steam hammers. The weight of the piston, piston-rod, and hammer-block, is 12½ cwt. or 1400 lb.

Mr. Henry Maudslay observed, there appeared to be two points particularly to be noticed in this hammer:—the simple mode of altering the lap of the valve, by the use of a cylindrical valve that could be turned round by hand into any position between the two extremes of no lap or full lap; and the ingenious mode of attaching the piston-rod to the hammer-block, for overcoming the difficulty experienced in previous hammers from breakage of the piston-rod.

Mr. Peacock stated that there were now three of the hammers at work, all of the size shown in the drawings, one of which had been working eight months; the cost was about £175, exclusive of the anvil. The valve is worked by hand with the greatest ease, being made hollow for the steam to pass through, so that it is completely balanced; and having a lap half round the circumference at the top end, it could be turned round by hand so as entirely to prevent the steam entering above the piston, for giving light finishing blows with the hammer. The chief object in the hammer is its simplicity of construction, by the absence of gearing for working the valve; it is not likely to get out of order while the working is completely controlled by hand. It is found particularly serviceable for smith's work where no two blows are wanted alike. The length of stroke is varied entirely by the hand-lever, which can be done to a great nicety after a little practice.

Mr. F. J. Bramwell had long been convinced that gravity alone was not sufficient for working steam hammers, because a great part of the effect was lost whenever the height of fall was diminished by having a large mass on the anvil. He had aided in devising a steam hammer some years ago, for crushing ore and also for forging iron; the falling weight was 30 cwt., but by using steam on the top of the piston the force of blow of a large hammer was got out of a small one, with a rapidity of stroke that could not be attained by gravity alone. The piston-rod was made very large—half the area of the piston—so that the steam had only the annular area to lift by; and for the down-stroke the steam was exhausted from the bottom of the cylinder into the top, where it acted upon the whole area of the piston, producing

---

* From a paper read at the Institution of Mechanical Engineers.

STEAM HAMMER.

Fig 1.

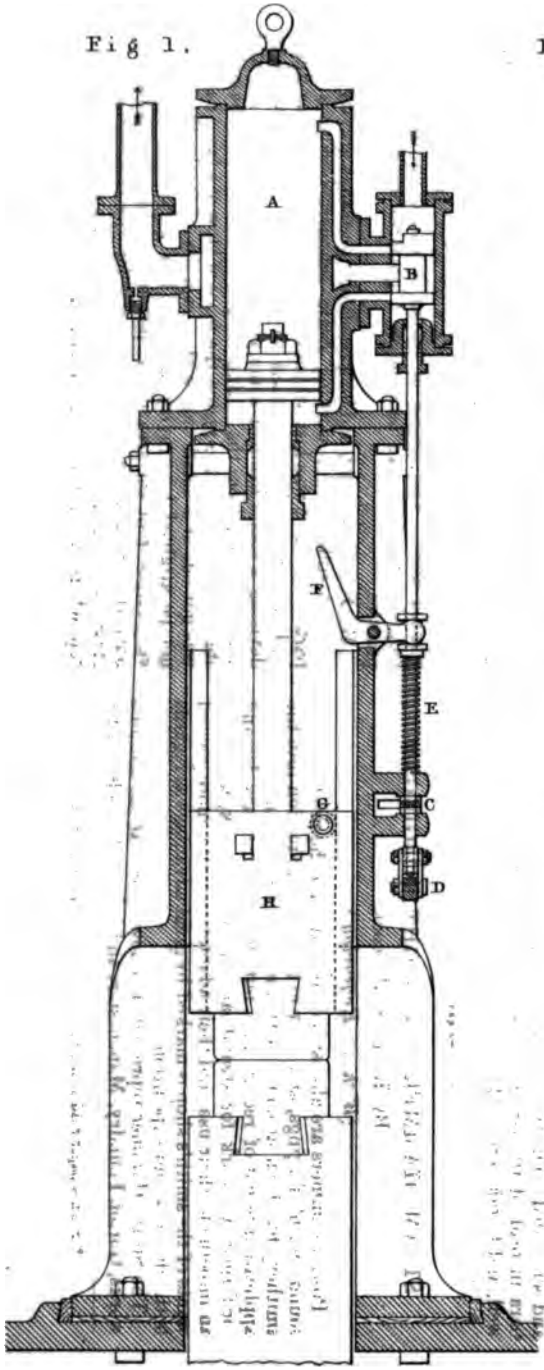


Fig. 2.

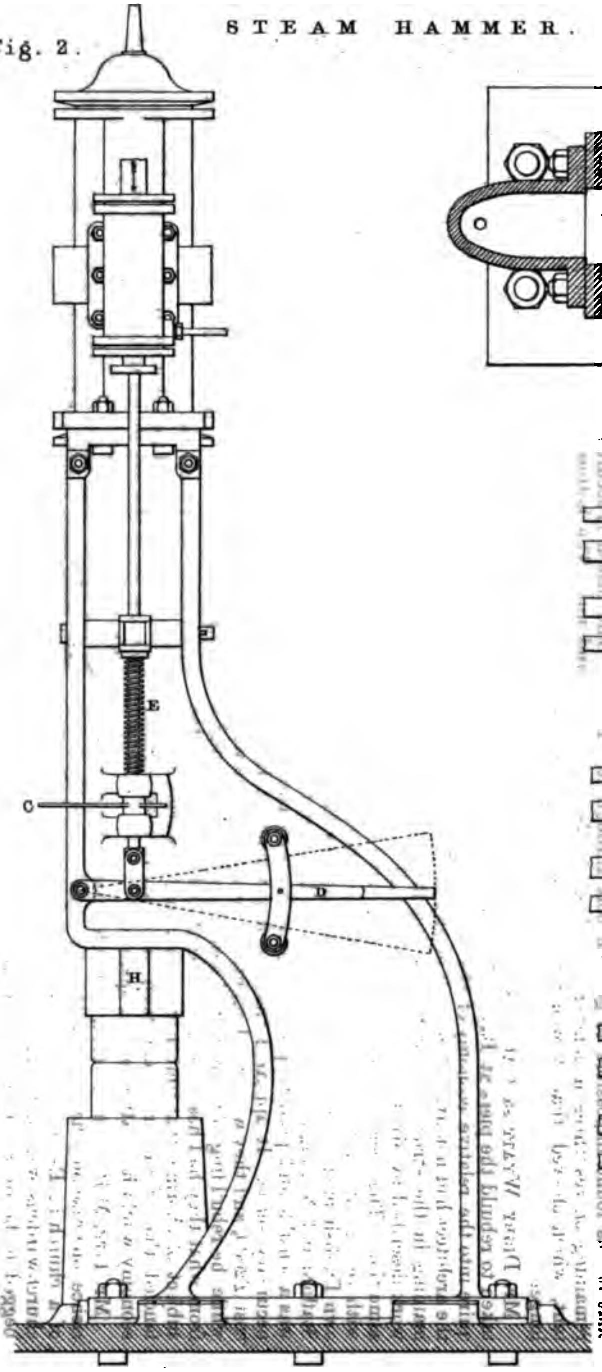


Fig. 3.

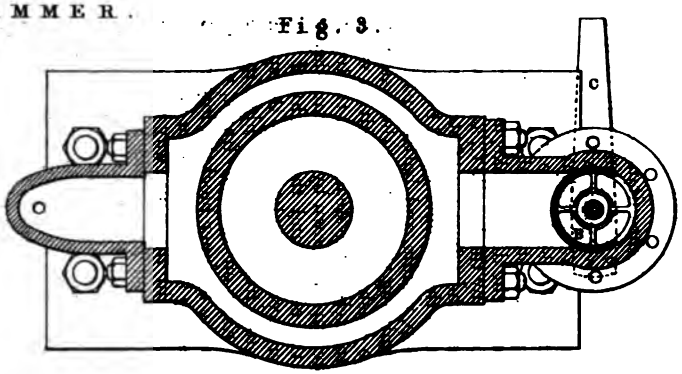


Fig. 4.

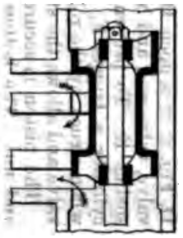


Fig. 5.

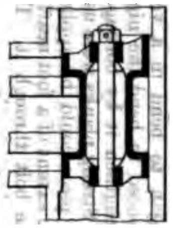


Fig. 6.

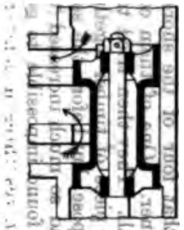


Fig. 7

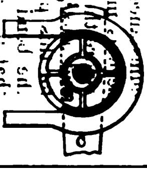


Fig. 11.

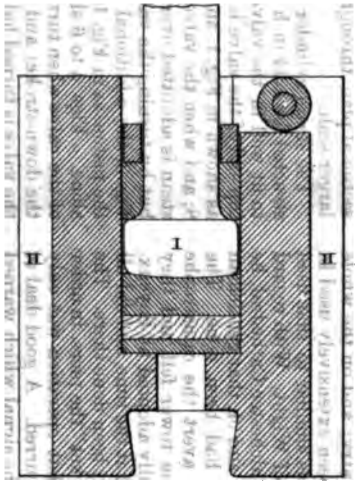


Fig. 12.

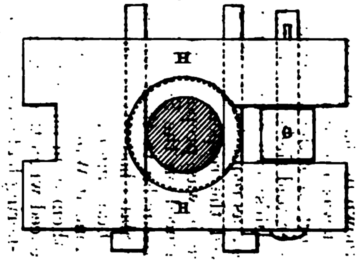


Fig. 8.

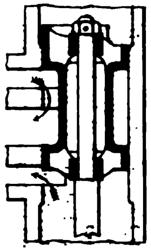


Fig. 9.

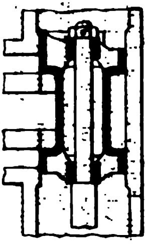
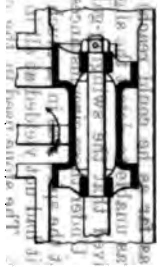


Fig. 10.



a total effective pressure corresponding to half the area. Two of these hammers had been put to work at Rotherham about six years ago, and continued working there satisfactorily. The principal difficulty he had experienced was in attaching the piston-rod to the hammer-block, which had been done in the first hammer with two keys driven in horizontally from each side, and with wood packing to produce a certain amount of elasticity; but the keys got loose with the jarring of the blows, and came out. To prevent this they were put in obliquely, inclined downwards, which caused them to remain secure; all elastic packing in the hammer-block was abandoned, the keys being driven in tight to make a rigid attachment; and this plan succeeded entirely. The connection of the piston also to the rod was frequently a difficulty, and he thought the best plan was to forge it solid on the rod, and make it steam-tight with Ramsbottom's packing rings, so as to have as light a packing ring as possible. Where a steam hammer was required, he doubted whether it was ever desirable to work it without any steam on the top; but the valve now shown would be very useful for altering the degree of lap and varying the admission of steam above the piston.

Mr. E. A. Cowper observed that the loss of steam in working the hammer at a short range with steam above the piston would be greatly reduced by the plan mentioned by Mr. Bramwell of enlarging the piston-rod, and using the same steam above the piston that had previously lifted the hammer: the additional work got out of the steam in the down-stroke was then all gain. He believed all steam hammers required steam jackets quite as much as the cylinders of steam engines; for if there were any moisture on the surfaces of the cylinder, it showed that a quantity of steam was passing through without doing duty, being merely condensed in the cylinder and then evaporated again.

Mr. Peacock said that the addition of a steam jacket round the hammer cylinder is desirable where economy of steam is of importance. Cushioning is necessary for lifting the hammer again more readily after the blow, and to insure lifting it clear without a repetition of the blow. The valve is worked by a boy, according to the smith's directions. As to the mode of attaching the piston-rod to the hammer-block, so as to make a good and durable connection; the hammer-block being made of wrought-iron, with a bore-hole carried right through, in order to get the boring bar in for boring the upper portion of the block. A hard wood packing of oak, teak, or ash was inserted in the bottom of the block between two wrought-iron washers, against which the bottom of the piston-rod bore with a cheese-head, $\frac{1}{4}$-inch smaller in diameter than the hole in the block; above the cheese-head was another washer, and then two cotters one on each side of the rod, which avoided weakening the rod by cutting cotter holes through it. The hammer was then put to work, and the cotters gradually tightened up; and after a week's work new cotters were put in slightly larger, so as to fit tight, which would then last for three or four months without any attention. At the bottom of the cylinder an ordinary stuffing box is used: the piston is made with two of Ramsbottom's packing rings, which would remain steam-tight for eighteen months or more without taking out, and he had had a Nasmyth hammer working with them for four years. He was now making a 4-ton hammer on the same construction, in which the exhaust side of the valve would be made longer than the distance between the ports, in order to prevent a vacuum being formed above the piston in falling when working single-acting, by allowing some of the exhaust steam from below the piston to pass into the top of the cylinder. He had never had any cotters broken during eight months' work; and the attachment of the piston-rod and hammer-block continued perfectly fast. The valve is designed as a simple form of balanced valve, that can be cast all in one piece, and requires only turning up on the outside, without any fitting. For ordinary smith's work the hammer is oftener wanted without the steam on the top than with it; but in forging work under dies very heavy blows are required, and it is a great advantage then to have the means of increasing the force of blow with the same hammer. By dispensing with gearing for working the valve the construction is much simplified, and the hammers are found to be handier for the men than a Nasmyth 15 cwt. hammer worked by gearing in the same shop; the boys who work the valves get quite perfect in managing them after three or four days' practice, and give exactly the force of blow the smith directs. There is a roller fixed on the hammer-block, which comes against a trigger connected with the valve-rod near the top of the stroke, and shuts off the steam in time to prevent the hammer rising too high.

Mr. W. Naylor doubted whether the same accurate adjustment of the blow could be got in working the valve by hand, as when gearing was used: in a rapid play of blows he thought the hammer would only just touch the anvil, without giving much force of blow, and the valve would have to be reversed some time before the piston reached the top of the cylinder, to prevent any chance of keeping the steam on too long. He had found the great desirability in a forge of having a hammer that could be worked single or double acting, as required; for when the iron was brought under the hammer at a welding heat, it wanted light quick blows at first for welding it together, and then heavy blows for working it into shape, which could be done with a double-acting hammer at the same heat; and the fewer heats the work had to go through, the better and quicker it was done.

REVIEWS.

A Rudimentary Treatise on the Acoustics of Public Buildings; or, the Principles of the Science of Sound applied to the purposes of the Architect and Builder. By T. Roger Smith, M.R.I.B.A. —London: John Weale. 1861.

Of all departments of physics, those are perhaps the most difficult to elucidate in which very familiar phenomena are to be traced to causes not only subtile in nature but diverse in operation, and not readily brought to square with the results of preconceived theory. There will always be a strong general persuasion that facts coming under daily cognisance are of course perfectly well understood, and can hardly offer a reward to study. At the same time, the few who labour to analyse them are often obliged to confess to a variance between logical deductions and actual observations, hard to explain in any other than a conjectural way. It is therefore scarcely matter of surprise that the number of English works on Acoustics is so small: the best treatise (that by Sir John Herschel) having been written more than thirty years ago. On the branch of the subject specially important to the architect—viz. its practical application in buildings, the existing books are no more than can be told off on the fingers, and anything approaching a complete and exhaustive treatment of it has hitherto been to seek. The work before us supplies what has so long been wanting; a clear and comprehensive handbook for the guidance of those who have to construct public buildings, showing how to achieve success and avoid failure in the vital matter of the *hearing* qualities of such structures. It is satisfactory to find that this task has been undertaken by a competent hand. The author is already known as having read a paper on Acoustics before the Institute last December,* and also one on the same subject before the Architectural Association, two years earlier. The book now under notice appears really to exhaust the question as far as it is at present understood, besides indicating points not as yet wholly removed from the province of conjecture, on which further observation and experiment may be expected to throw clearer light. As a rudimentary treatise it fully redeems its promise, being not only a comprehensive but a thoroughly practical and intelligible compendium of the lessons derivable from research or experience on the acoustic qualities of buildings.

It will be a comfort perhaps to many purely technical readers to learn that the "Science of Acoustics" is strictly confined to one small separate section of the book; so that, although the deeper principles that underlie the subject have evidently been present to the mind of the writer throughout the other portions of the work, they have been scrupulously kept from appearing on the surface. Simplicity and clearness have been thus much promoted; but they must be mainly attributed to a more important circumstance. While every accessible book of authority or value (not in English alone, but in other languages) seems to have been consulted, and, where occasion required, put under contribution, the results of such study, as well as those of observation, have manifestly been subjected to the scrutiny of a mature judgment. The treatise is consequently, as its plan and manner of handling abundantly show, the offspring of original thought; and the consequence is, that it gives in lucid and available order an amount of instruction and information that could not be presented in a mere compilation of double the size. The author has not hesitated to avow the leanings of his own mind on some few questions which can hardly as yet be said to be settled by general consent. But he always gives it to be clearly understood in such cases that the matter belongs to the province of opinion. And it is not the least of the recommendations of a practical work on what must still be called a young science (and, it is to be hoped, a growing one), that it distinctly *defines* the various obstacles and auxiliaries to sound, and also distinguishes what is known from what is only conjectured. It thus offers help and guidance to the architect in forming an intelligent and independent judgment on the results of his own personal experience. Such a book has an intrinsic value beyond even that of the positive information it directly conveys.

---

* Reported *ante*, pp. 2 and 46.

Glancing at the first section of the work, we find the "Science of Acoustics" very satisfactorily treated, although with brevity. We may, in passing, notice what, as far as we are aware, has not appeared in an English work before, and that is, a very lucid explanation (from Pouillet) of the nature of a "sound wave." The different kinds of action that take place in the mass of air, on the one hand, when it is simply *conveying* sound, and on the other hand when it becomes in itself *sonorous*, are also distinctly exhibited. The following remarks on the induced vibrations by which certain bodies are capable of reinforcing sounds excited near them, are of interest:—

> "This is true not only of such bodies as when excited give out a distinct musical note, but of others which cannot be said to have any sound peculiar to themselves. . . . . These vibrations, which we may call *sympathetic* vibrations, are of great value in reinforcing an original sound, and adding to it a character that it did not naturally possess, and for such a purpose the second class of substances are the most valuable, and among them, thin plates of wood eminently so.
>
> It is the power of setting a large mass of wood in vibration that gives the *tone* to all stringed instruments, and it is a matter well understood that the variations which make one violin or one piano-forte to be so much more valuable for musical purposes than another, do not lie at all in the strings that are put into *direct* vibration by the musician, but in the qualities of the reinforcing body, which those strings throw into *sympathetic* vibration.
>
> These vibrations are ordinarily communicated through the air; and, referring to that mode of inducing motion, Herschel observes: 'Just as a small pull, repeated exactly in the time of its natural swing, will raise a great bell, or a trifling impulse a heavy pendulum, so the molecules of air in a state of sonorous vibration will impress on any body *capable of vibrating in their own time* an actual vibratory motion, and if a body be susceptible of a number of modes of vibration performed in different times, *that mode only will be excited which is synchronous with the aerial pulsations.*' If, however, the exciting and excited body are in actual contact, the induced vibrations will be the more vigorous, and they will even display an amount of motive power out of all proportion with the original exciting cause.
>
> 'To show this in a striking manner,' says Pouillet, 'it is only needful to connect a little tube of glass to a large beam of wood, and then to excite vibrations in the tube by rubbing it with a wetted cloth; at once the entire mass of the beam will enter into longitudinal vibration, lengthening and contracting itself; and an enormous weight acting by tension or by compression would be required to cause the same changes that a very light rubbing can excite.'"

The result, when put in this form, seems sufficiently startling; yet a moment's reflection will serve to show that it is quite in accordance with physics. To raise a pendulum a given distance from the perpendicular, or to shorten a beam of wood by direct compression, each involve a certain amount of "work," requiring a commensurate force. But when the pendulum is oscillating, or the beam alternately contracting or expanding to equal degrees, the amount of work done during each complete pulsation is virtually *nil*. It is therefore evident that there is nothing in the phenomenon of the "reinforcement of sound" that implies the spontaneous propagation of force, or is in any way at variance with dynamics.

The second section gives a remarkably lucid account of the Obstacles and Auxiliaries" to sound in buildings, which essentially exhausts all that is known on the subject. The obstacles are arranged under the heads of "decay, absorption, obstruction, reverberation, and echo." In treating of absorption the writer observes,

> "It may be proper to note that although for convenience we have included two agencies adapted to diminish the volume of sound under the head *absorption*, a distinction will often be perceptible in their effect on sound. Soft surfaces deaden and destroy its quality, but do not much affect its distinctness; they are therefore more injurious to music than to speaking. Large spaces of air frequently themselves become resonant, and while they impair distinctness may yet improve the quality of sound; they are therefore more objectionable where speaking is contemplated than for music, unless the instruments or the singer be deficient in power; and, although rooms having these defects—like all rooms bad to hear in—are unpleasant to a speaker, yet the unpleasantness is not of the same sort. In the first-mentioned cases, *i. e.* when soft surfaces are in excess, a sense of oppresion upon the voice, and a sort of deadness and heaviness are complained of; in the second case, the sonority possessed by all large masses of air often renders speaking or singing agreeable, and entices the speaker to make an unusual effort to fill the room, till after a short time he becomes wearied by the exertion required and the consequent exhaustion; while the auditors are also dissatisfied, because though what they hear is spoken loud enough, and is really heard, it does not *distinctly* fall on the ear, but is heard encumbered and confused by secondary sounds that prolong each syllable into the next."

Reverberation is explained to denote a confusion of sound, arising either from excessive resonance or from indistinct and incomplete echo. As to the former—

> "In the avoidance of actual reverberation, notwithstanding a near approach to it, will lie the great skill of an architect; or, in other words, the greater the amount of genuine resonance he can introduce into his building the more agreeable will be the effect it will have upon the human voice, and musical instruments of all descriptions."

Among the features in rooms that are apt to occasion that unpleasant kind of reverberation that results from indistinct echo, the author mentions "smooth, unbroken, and lofty plastered walls and plastered ceilings." In many instances—

> "The hardness of the surfaces presented by the walls seems to help to render the rooms noisy, and this is always likely to recur where hard, smooth linings are employed. It is fair to admit that the opinions of some of the writers to whom repeated reference has been made, have been very decidedly expressed in favour of the employment of hard substances for the material, and smooth plaster for the lining of the walls that are to contain an auditory. Lachez and Rhode agree in this view, in which nevertheless it appears impossible to concur with them. Were it only desirable to obtain the greatest amount of sound possible, or, in other words, the loudest noise—regardless of quality or distinctness, we no doubt ought always to employ the most perfect of reflectors, just as we line such a room as a French *café*, which we wish to render dazzlingly brilliant, with mirrors. If however we desire purity of tone, it will be better to seek it in the musical tremor of wooden linings than in the conduction and rattling reverberation of hard polished surfaces; just as with the same aim as regards light we should, in rooms where quiet brightness is desired, replace the mirrors by bright but lustreless linings of paint or paper, or by light coloured draperies."

The *auxiliaries* to sound which buildings can afford are enumerated under the heads of reflection, conduction, and resonance, and are discussed with much aptness of illustration, and (if we may so say) a rare common-sense—no mean merit in a work on such a subject. We observe that Mr. Smith brings forward very distinctly the importance of resonance as an auxiliary not simply to the intensity but also to the quality of sound. A reference to the resounding-vases or *echeia*, employed by the ancient Greeks for the sake of resonance in their theatres, gives occasion for a comparison, which seems happy and probably just, between their sympathetic action and that of the quiet pipes of an organ, which, "even when the instrument is not made use of, will be of some service to the tone of other musical instruments, or of the human voice." In brief, our author concludes that the expedient of the *echeia* seems to have been founded upon sound principles; an opinion which few will dispute.

The third and concluding section, under the title of "Applications," gives an able review of different classes of public buildings, illustrated by examples in such a way as to afford important guidance to the architect. The arrangement here adopted is a new one, and an improvement on the mode of grouping followed in the paper read before the Institute to which reference has already been made. Sections and plans on wood are given of three buildings, each excellent of its kind—viz. the Lecture Theatre of the Royal Institution in Albemarle-street, the Free Trade Hall in Manchester, and the Surrey Music Hall. The last are valuable as the only complete published set of drawings (we believe) of an admirable but ill-fated building. And as a melancholy interest now attaches to the record of this noble instance of skilful acoustic construction, we cannot forbear extracting it.

> "The Surrey Music Hall is a very good example of a successful hall of large size. We have here a light construction, surrounded by tiers of galleries one above the other, having a lofty roof on a series of internal columns, and the floor on the level of the grounds with which it communicates directly by its many doors, just as the galleries open into the balconies that surround them. The points of similarity (with the Man-

chester Free Trade Hall) are the general disposition of the building (an oblong with the orchestra at one end), the care taken to give suitable forms to the end of the hall, the section of the roof, the front of the galleries, &c., the recess for the orchestra, the good proportions, the restricted mass of air in the building, the careful avoidance of echo, and the judicious employment of resonance to support the voice or instruments.

The general form of this hall may be described as an elongated octagon or a parallelogram, with semi-octagonal ends, into which the walls of the staircase project, so as to form them into recesses.

There are three tiers of galleries, supported on light iron columns, and with fronts of curved section. The ceiling over the central space is of domical section, and that over the galleries inclined.

The very steep rise of the orchestra cuts off a great deal of vacant space behind the performers, and the roof comes down over them; but in order further to restrict the space, a large sounding-board, made of old well-seasoned wood was hung over the orchestra. The forms, it will be seen at a glance, are well chosen throughout the building, and the proportions are also good. The extreme length is 163 ft. 6 in., the width 68 ft. 6 in., and the height to the underside of the ribs of the ceiling is the same; so that the width is to the height and to the length as 1 to 1, and 1 to 2½. The main reliance of the architect was, however, on the use of resonant materials, and these were employed freely. Besides the woodwork of the galleries and orchestra, and the wooden sounding-board, the whole walls were lined with boarding on battens, with a special view to promote resonance, and the ceilings, which are plastered, were originally intended to be of wood, for the same purpose. The success of this hall both for music and public speaking was complete. Very large audiences, which have been differently stated, but cannot be estimated at fewer than 8000 people, and probably much over that number, have been able to hear perfectly in even the remotest parts of the building; and, vast as it is, even professional musicians consider it one of the best music-rooms, large or small, in the metropolis."

We are not sure that the given dimensions come close enough to the stated ratio to render the Surrey Hall conclusively an instance of the effect of good proportion in a building. But all will concur in the justice of the views expressed as to the configuration and the materials. It further suggests itself as highly important (remembering the fate of this hall and of the St. Martin's Hall), that where resonance is secured by the free employment of large surfaces of thin wood, corresponding care should be bestowed both in the provision made against fire, and in affording very ample and speedy means of egress for the auditory.

In conclusion, we strongly recommend this treatise to our readers. It is a book that should be in the hands of every architect who does not wish to confine his practice to the construction of private or commercial buildings. It also contains much that should be known and understood by many who are not architects, especially by those who have any interest in the erection of public edifices, sacred or secular. This is the last in order of publication (though not of enumeration) of Weale's Rudimentary Series, of which it thus forms the final volume. Mr. Weale has long since stood pledged to bring forward a Rudimentary Treatise on Acoustics, and we can now speak to his promise having been most satisfactorily performed. One or two typographical corrections are needed—especially two in the author's name as given on the cover—for which we trust a second edition will furnish early opportunity.

The Theory and Practice of Ship Building and Steam Ships By ANDREW MURRAY.—Edinburgh: A. and C. Black.

Messrs. Black have commenced publishing as separate treatises some of the most important articles in the seventh edition of the 'Encyclopædia Britannica,' just completed; and those on Ship Building and Steam Ships, by Mr. Murray, who is chief engineer and inspector of machinery of the Dockyard at Portsmouth, are of the number. By the adoption of this plan the valuable treatises contained in the Encyclopædia are rendered accessible to those who are more immediately interested in the special subjects treated of, and many who would otherwise be unable from the costliness of the whole work to avail themselves of the information they particularly require, can thus for a comparatively small sum become possessed of the portions of the Encyclopædia in which they take the most interest. As the articles on Ship Building and Steam Ships appeared in one of the lately published volumes, there cannot be much to add to the original text, but Mr. Murray has taken advantage of the republication in the present form to introduce a notice of such improvements as have taken place in the interval.

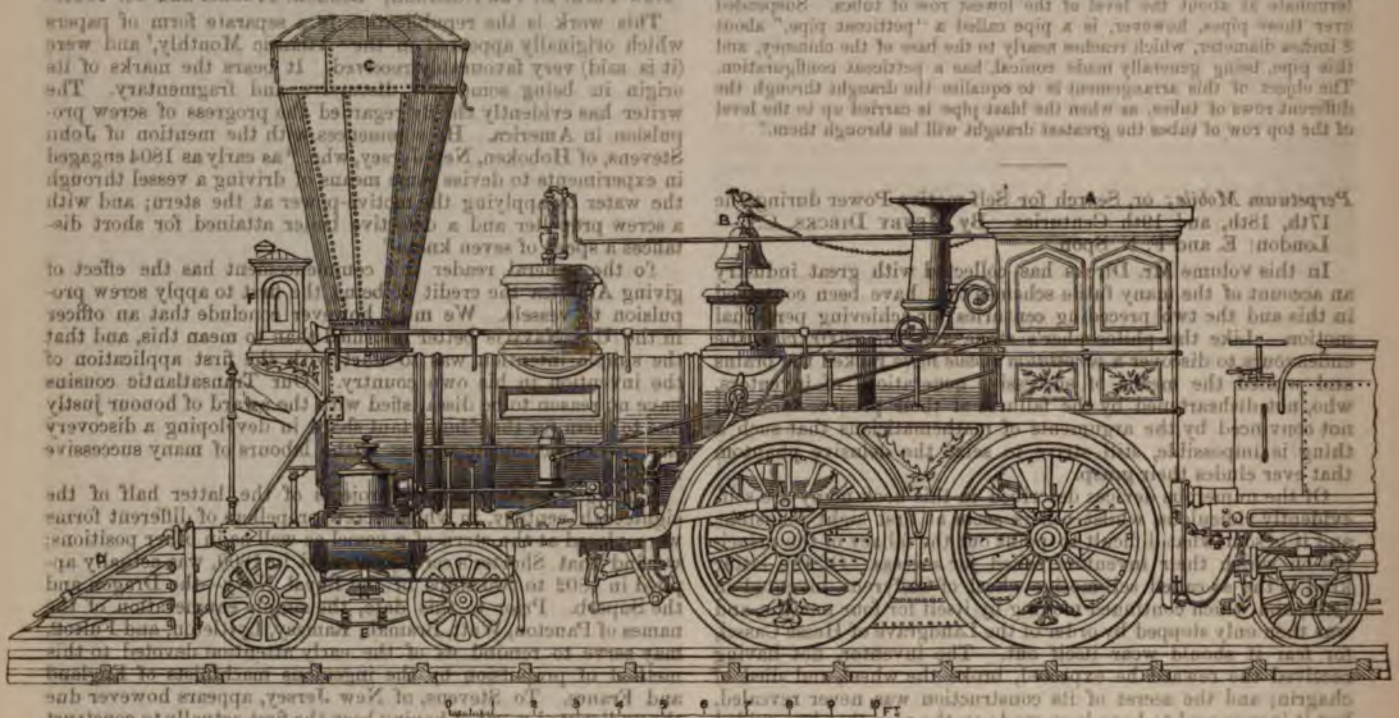
A Treatise on the Steam Engine in its various applications to Mines, Mills, Steam Navigation, Railways, and Agriculture. By JOHN BOURNE. Fifth edition. Longman and Co.

The so-called "Treatise on the Steam-Engine by the Artisan Club," which was originally published in numbers, has met with so much public favour as to have run through four editions; and it now presents itself in a greatly enlarged form, the additions and emendations being so numerous and extensive as to render the work substantially a new one, as stated in the preface. It is, indeed, a very complete compendium of knowledge, theoretical and practical, of all matters relating to the application of steam-power, and it enters into details of construction with a degree of minuteness not elsewhere seen in general treatises. Commencing with a full history of the invention of the steam-engine, which is illustrated with numerous wood-engravings of the principal engines and parts of engines that were constructed in its progressive improvement, the author next proceeds to consider the scientific principles of the steam-engine, its general theory, and its proportions, and the construction of boilers; and after describing the many varieties of engines, he devotes three chapters to steam navigation, to projects of improvement in the steam-engine, and to rules and tables for finding the proper proportions. Every branch of the subject is closely investigated in an original manner, for the author evidently prides himself on having shaken off the shackles of conventional opinions. Some idea may be formed of the minuteness with which he has entered into these considerations by the number of illustrations, of which there are thirty-seven lithograph engravings, and upwards of five hundred woodcuts. The details of construction are given in many instances with as much particularity as if they were working drawings, and the illustrations of the machinery of the Great Eastern, of the new Holyhead steamers, and of other steam-ships in which inventive genius has been exercised for the perfection of steam navigation, show that the author has brought the work closely to the present state of knowledge. The principal value of this treatise consists in its practical illustrations, for the theoretical and scientific portions of it will frequently not bear examination. There is, indeed, an exhibition of presumption and dogmatism in many parts which tend to give an unfavourable opinion of the work; and in some of the scientific principles, in which the author presumes to differ rather contemptuously from established opinions, he is manifestly wrong,—we allude more particularly to his notions respecting the nature and laws of motion. The clumsy fiction that this treatise on the steam-engine was written by the "Artisan Club"—a body which had never any existence—appears to be abandoned, or very slightly retained in this edition, for Mr. Bourne takes the entire credit of it to himself, and he vauntingly observes that, "On looking through its pages I see no reason to be dissatisfied with its general quality, or the manner of its execution." It is somewhat unusual for an author thus to blow his own trumpet. The same spirit pervades the work, and, combined with the representation that it was the production of a non-existing "club," tends materially to detract from our estimation of its merits.

It is scarcely worth while to discuss the fallacies of some of Mr. Bourne's "scientific principles," for it would lead to a lengthened consideration of matters that are generally well and correctly understood, though he calls them "erroneous;" nor shall we say more of the theory of the steam-engine, to which especial attention is called in the preface to the third edition, than that it is characterised correctly by himself in the preface to the first one, in which it was stated that the theoretical part had been confided to some mathematical assistants, "in whose superfine speculations the engineer may perhaps discern the hand of a tyro." It is the practical part of the work in which its value consists, and it will be found to contain a vast fund of useful information in every mode of applying steam-power. The following description of an American locomotive may be new to some of our readers:—

> "The American locomotives differ considerably in several of their features from those which are employed in this country. The fore-part of the engine is usually supported upon a small four-wheeled truck or bogie. A large cone is placed around the chimney for catching the sparks, which are very inconvenient where wood is burned. A sort of inverted saucer over the mouth of the chimney deflects the sparks downwards into this cone, whence they are drawn off at intervals by a small door. The top of the cone is covered with wire-gauze, to intercept any sparks which escape being driven into the cone. In the front of the engine is an arrangement of bars of iron, called a cow-catcher, for throw-

ing any object off the line which may happen to be upon it; and this apparatus also acts like a snow-plough, should snow have fallen on the line. The diagram is a side elevation of a common form of American locomotive. A is a shed or short carriage for protecting the engine-driver from the weather. B is a bell which is rung when the engine approaches stations. C is an inverted cone round the cylinder to catch the sparks from the furnace. D is the cow-catcher. E is the truck or bogie by which the fore-part of the engine is supported; and F is a lamp to give light by night. The driving-wheels are generally four in number, coupled together. They are commonly from 5 feet to 5 ft. 6 in. in diameter, or, when great speed is required, they are 6 feet, and sometimes 7 feet in diameter; but it is almost the invariable custom to use four coupled-wheels for all speeds. The coupled-wheels are placed about 18 inches asunder. The hind pair is furnished with flanges, but the leading driving-wheels are usually without flanges, and are commonly cylindrical instead of being somewhat coned. The cylindrical wheels are said to wear much better than the coned, and to cause less oscillation. For working steep inclines, engines with eight wheels coupled, from 2 ft. 6 in. to 2 ft. 9 in. diameter, are employed. These wheels are usually of chilled cast-iron. It is usual to make the driving-wheels of passenger-engines with cast-iron centres and wrought-iron tires, but sometimes the tires are of chilled cast-iron, which is said to be better fitted to endure the frost.



ELEVATION OF ENGINE AND PART OF TENDER IN GENERAL USE ON RAILWAYS IN THE UNITED STATES.

In the heavy engines employed in transporting coal on the Reading Railway, and which burn anthracite coal, there are eight coupled-wheels of 48 inches diameter, and the cylinders are 19 inches diameter and 22 inches stroke. The boiler is 46 inches diameter, and contains 103 iron tubes, 2¼ inches external diameter, and 14 feet long. The furnace is 7 feet long, and the bars are cast in pairs, and are made movable by a lever, so that the clinker may be readily broken up. The ash-pan is made to contain a few inches of water to prevent the bars from being burnt out. A good deal of coal is said to be wasted in these engines, from being carried up the chimney by the draught, and a good deal by falling through the bars of the grate. Upon the whole, anthracite coal cannot be said to have been very successfully introduced in locomotives. It is severe upon the furnace, and the evaporative efficacy reached does not appear to be more than 7 lb. of water per pound of coal, which is a good deal less than is obtained with coke.

There are no buffers between the engine and tender of American locomotives, but a wedge is interposed beteeen the abutting surfaces to obviate shocks. In the various carriages of the train, central buffers alone are used. The whistle is larger than that used on the English lines. Glass gauges are not found to stand, and four or five gauge-cocks are employed. The feed-pumps have air-vessels both on the drawing and the forcing sides. The link-motion is in universal use. The axle-boxes are usually made close, and are supplied with oil, and provided with leather washers to keep the oil in. Slices of salt-pork have been lately used for packing the axle-boxes, and the result is stated to be satisfactory and economical. The boxes do not require to be packed or oiled more than once a month. The boxes are sometimes of bell-metal, sometimes of a composition of 92½ parts of zinc, and 7½ parts of copper, and sometimes are lined with, or wholly composed of, soft metal.

To give toughness to the cast-iron wheels, they require, after having been cast in a chill, to be annealed. The wheels therefore, so soon as they are set, and while yet red-hot, are transferred to pits which have been made very hot by anthracite fires. The pits are hermetically sealed, to prevent the admission of air, and after three days the wheels are taken out, when the annealing process is found to be completed. The annealing does not affect the chill of the tire, which is half-an-inch deep, as the operation of chilling takes place when the metal sets. It is necessary however, with these chilled wheels, to be careful not to apply the brakes too suddenly, so as to occasion slipping on the rails, as the friction takes out the chill at that spot, and causes a flat soft place to form on the wheel, which destroys it altogether. Brake-blocks of cast-iron are used in some cases, and are found to be preferable to wood. The brakes are set by winding a chain in connection with them on an upright barrel, having a hand-wheel at the top. In cases of emergency it has been proposed to work the brakes by a friction-wheel, which may be instantly pressed down on the driving-wheel of the engine. A cord is carried along the top of every carriage of the train to a large gong-bell placed on the engine. This cord is formed in lengths equal to the length of a carriage, and the pieces are connected together by means of metal snaps. A small shaft led along the top of each carriage, with square or triangular ends and sockets, and universal joints, would be an equally simple arrangement. It is not found practically in America that there is any trouble in connecting the cord to the new carriages when a change in the carriages takes place.

The American locomotive carriages are of much larger dimensions than those which are employed in this country. The bodies are commonly made about 45 feet long, 9½ feet wide, and 7 feet high. The carriages are open from end to end, and at the ends doors are placed, opening upon platforms protected by railings, and establishing a passage between one carriage and the next adjoining. From the platform stairs descend, by means of which passengers enter or leave the carriages. The seats are ranged on each side of a central passage, and the backs of the seats are made to turn either way. On the roof of the carriage ventilators are placed, and there is a stove to warm the carriage in winter, and a supply of drinking water. To prevent the dust from rising, a canvas curtain has been introduced outside the wheels on some lines, extending from the carriage-floor to the ground, whereby the dust is prevented from being sucked up by the motion of the train. In other cases jets of water propelled by a centrifugal pump, moved by a friction-roller resting on one of the wheels, have been introduced in an air space on each side of the carriage, through which the air is admitted; and the air is thus cooled and freed from dust by the same operation. The carriages rest at each end on a truck or bogie with four wheels, and the wheels of each bogie are as far apart as the distance between the rails, so that the plan of such a truck forms a square. India-rubber springs have been tried, but the result has not been satisfactory, and plate or volute springs are now usually employed.

In all the American locomotives, the internal fire-box is considerably smaller at the top than the bottom, so that the sides are much inclined, whereby the escape of the steam from the surface of the metal is facilitated, and the overheating of the plate prevented. The fire-boxes are almost universally of iron. The tubes of the boiler are generally of copper—few iron or brass tubes being in use, except that in engines using anthracite coal iron tubes are used to diminish the wear caused by the hard particles of coal carried up by the draught, and which the copper cannot so well withstand. The general proportions of the American locomotives do not differ materially from those prevailing in England. On the whole, however, the blast-pipes require to be smaller and the draught more intense, for engines burning wood, to maintain sufficient vividness of combustion; and the disposition now is to place the tubes farther apart than formerly. In some engines it has been found that an increased supply of steam was obtained by removing some of the central tubes, and the tubes are never placed closer than three-fourths of an inch apart.

There is a separate blast-pipe from each cylinder, and these pipes terminate at about the level of the lowest row of tubes. Suspended over these pipes, however, is a pipe called a "petticoat pipe," about 8 inches diameter, which reaches nearly to the base of the chimney, and this pipe, being generally made conical, has a petticoat configuration. The object of this arrangement is to equalise the draught through the different rows of tubes, as when the blast-pipe is carried up to the level of the top row of tubes the greatest draught will be through them."

Perpetuum Mobile; or, Search for Self-motive Power during the 17th, 18th, and 19th Centuries. By Henry Dircks, C.E.—London: E. and F. N. Spon.

In this volume Mr. Dircks has collected with great industry an account of the many futile schemes that have been contrived in this and the two preceding centuries for achieving perpetual motion. Like the philosopher's stone and the *elixir vitæ*, the endeavours to discover a *perpetuum mobile* have racked the brains and wasted the means of successive generations of inventors, who, not disheartened by the failures of their predecessors, and not convinced by the arguments of mathematicians that such a thing is impossible, still strive to seize the delusive phantom that ever eludes their grasp.

Of the numerous devices described in this book many are self-evidently ridiculous, whilst others seem at first sight plausible, and it is somewhat difficult to point out the fallacy of the principle on which their inventors relied for success. Of the latter kind is the so-called self-motive wheel of Orffyreus, invented in 1717, and which continued moving by itself for four months, and was then only stopped by order of the Landgrave of Hesse Cassel, for fear it should wear itself out. The inventor, not having received the reward he expected, broke the wheel, and died of chagrin; and the secret of its construction was never revealed, but it is supposed to have been made on the plan that has guided the construction of numerous subsequent self-motive wheels,—of attempting to overcome the counterpoise in the ascending part of the wheel by throwing the weight near the axis. This is done by constructing a drum turning on an axis with curved internal radii, inclosing in each compartment either a leaden ball or a quantity of quicksilver. It must be admitted that Dr. Hutton's explanation of the fallacy of this notion is not satisfactory, and he is obliged to resort to the negative proof that such a wheel has never been made to turn of itself; that of Orffyreus being suspected to have contained clock mechanism worked by a strong long-sustaining spring.

Mr. Dircks, though he condemns and ridicules the folly of attempting to produce a self-motive machine by the means hitherto adopted, considers such a thing not impossible; for, as he observes, "incessant failure does not of itself offer sufficient argument against the possibility of perpetual motion." He has recorded in this volume a vast number of such failures, which excite pity for the men who could throw away their time and money in schemes that are ridiculously impracticable. Among these we find, more than once repeated, an attempt to gain perpetual motion by attracting a steel ball by a magnet up an inclined plane, near the top of which there was a hole through which the ball was to drop and run down to the bottom of the inclined plane, to be again drawn up. Another plan, frequently attempted, was to turn a wheel by the flow of water from a cistern, the motion of the wheel being applied to work an Archimedean screw, by which the water was to be raised again to the cistern! Some of the inventors noticed were so confident of success, that they thought the only difficulty which presented itself was, how to stop the machines when once set in motion. There seems to be something very fascinating in the pursuit of this *ignis fatuus*. One artisan whom we knew, who had saved a considerable sum, spent it all in making an apparatus to be worked by centrifugal force; and he adduced the authorities of Newton and Maclaurin to prove that it was constructed on sound principles. He conceived he had been divinely inspired to make known his plan of perpetual motion to mankind. Such men will continue to grasp at the shadow and lose the substance, whatever may be said to expose their folly; but it will be of use to them to consult this volume, where they will probably find that their schemes have been tried again and again, and have ended in failure and ruin. Its curious contents will be interesting also to the general reader.

Notes on Screw Propulsion. By W. M. Walker, Commander, U.S.N. New York: D. Van Nostrand; London: Trübner and Co. 1861.

This work is the republication in a separate form of papers which originally appeared in the 'Atlantic Monthly,' and were (it is said) very favourably received. It bears the marks of its origin in being somewhat discursive and fragmentary. The writer has evidently chiefly regarded the progress of screw propulsion in America. He commences with the mention of John Stevens, of Hoboken, New Jersey, who, "as early as 1804 engaged in experiments to devise some means of driving a vessel through the water by applying the motive-power at the stern; and with a screw propeller and a defective boiler attained for short distances a speed of seven knots."

To the general reader this commencement has the effect of giving America the credit of being the first to apply screw propulsion to vessels. We must however conclude that an officer in the U.S. Navy is better informed than to mean this, and that the simple intention was to start with the first application of the invention in his own country. Our Transatlantic cousins have no reason to be dissatisfied with the award of honour justly due to them for their important share in developing a discovery that owes its complete success to the labours of many successive inventors.

Passing over the various projects of the latter half of the eighteenth century, in which screw propellers of different forms were placed at the stern of a vessel as well as in other positions; we find that Shorter's screw, patented in 1800, was actually applied in 1802 to two ships of the Royal Navy—the Dragon and the Superb. Prior to this date, the simple enumeration of the names of Paucton, Watt, Bramah, Ramsey, Lyttleton, and Fulton, may serve to remind us of the early attention devoted to this method of propulsion by the ingenious machinists of England and France. To Stevens, of New Jersey, appears however due the undisputed merit of having been the first actually to construct and work a *screw steamer*,—a circumstance that entitles his name to honourable record.

In 1825, Samuel Brown, the inventor of the Gas Vacuum Engine, applied it to work a screw-propeller boat on the Thames, carrying thirty persons, and attaining a speed of 7 miles per hour. This interesting experiment was however chiefly intended to prove the capabilities of the motive power; so that the efficiency of the screw as a propeller was imperfectly displayed, owing to the comparative failure of the engine employed to drive it.

In 1832 Woodcroft patented a propeller with an increasing pitch. In 1836 Smith obtained his patent for screw propulsion. In the same year Ericsson patented his propeller. Smith made some experimental trips with a boat of 6 tons burden. The success of these trials led to the formation of a company, and the construction (by the Rennies) of the Archimedes.

In the Archimedes the screw consisted of a single thread of sheet-iron, bent to fit sixteen wrought-iron arms, fixed equidistantly round the axis, so as to form a helix, and being of very long pitch produced great disturbance in the water, and much vibration at the stern of the vessel. The first alteration was to cut out portions of the plate, so as to produce a kind of multibladed screw; but this produced no improvement, and the form of screw was then changed to a double one. The speed of the Archimedes was 9 knots an hour.

The Ericsson propeller (applied first to a small vessel called the Francis Ogden) differed entirely from the screw applied to the Archimedes. It consisted of a broad ring, connected to the axis by three arms, and carrying six inclined blades, the arms also being oblique. The Ericsson propeller did not however excite much attention in this country; but Capt. Stockton, of the U.S. navy, seems to have taken a warm interest in it; and in consequence, as we learn, of his representations the United States government caused the Princeton to be built, and thus established the Ericsson form of propeller in America. Capt. Walker states that the Princeton was launched in 1842; and, as he justly remarks, it was a most successful experiment in the application of the stern propeller to a vessel of war.

In 1843 a similar form was applied to the French frigate La Pomone, but subsequently the Smith screw, or modifications of it, became generally adopted in lieu of the Ericsson propeller. The Smith screw was patented and tried in 1836, the patent having been taken out two months before Ericsson's; and it was this screw that was first employed in the Archimedes. The success of the Archimedes led to the construction of other vessels, and to the valuable series of experiments undertaken by our own government with the Dwarf and Rattler. The latter attained a speed of upwards of 12 miles an hour, with Rennie's conoidal cast-iron screw, which had three blades. Capt. Walker alludes but cursorily to the Griffiths screw, and altogether omits Maudslay's feathering-screw, and other ingenious contrivances for the same object.

The horizontal trunk engine of Penn would appear to be equally well spoken of on both sides of the Atlantic.

> "These engines comply with all the conditions reasonably demanded in the machinery of a man-of-war: they lie very low, and the fewness and accessibility of their parts leaves scarcely anything to be desired; a lighter, more compact, or more simple combination has yet to be conceived."

No mention is made of Randolph and Elder's engines, which have attracted so much notice in this country for their lightness and unprecedented economy of fuel; nor in speaking of the high velocities required in direct-acting engines does the writer touch on the main difficulties that arise.

> "The form of engine generally adopted with great success in the later screw ships of the U.S. navy is the horizontal direct action, with the connecting-rod returning from a cross-head towards the cylinder; these engines make from 60 to 80 revolutions per minute. The steam-valve is a packed slide, with but little lap, and the expansion-valve is an adjustable slide working on the back of the steam-valve. The boilers are of the vertical water-tube type, with the tubes above the furnaces, and are supplied with fresh water by tubular surface condensers, which, together with the air-pumps, are placed opposite the cylinders."

Capt. Walker next gives some details of the advantages of being enabled to lift the screw, instancing the Voyerada, a Russian sloop, which having been unable, from an accident, to raise her screw, had her speed reduced to 4½ knots; as soon however as the lifting apparatus was repaired, and the screw raised, her rate of sailing increased to 6½ knots. It was also found that if the screw-blades were horizontal, so as to cause the fullest amount of "drag," the speed was still less—viz 2½ or 3 knots only. It is suggested that a slide or gate should be fitted to fill out the dead-wood when the screw is lifted, in order to obviate "griping," and the experiment certainly is well worth making. In relation to this we may remark that Maudslay's feathering-screw must have much the effect of the slide proposed when its blades are placed parallel with the line of the keel.

After some remarks on the relative strengths of the English and French navies, the author proceeds to consider the question of the speed required in vessels of war, going somewhat closely into the relative merits of full-powered and auxiliary-powered ships. He first suggests that screw steamers should be able easily to divest themselves of yards, topmasts, &c. and everything that can interfere with steaming powers, and that on returning to the use of sails the change may be speedily effected. In this he is no doubt right, and we think that much remains to be done in this direction before the highest degree of efficiency will be attained.

> "That measure of speed or power which will enable a ship to stem the currents of rivers, to enter or leave a port in the face of a moderate gale, or to meet the dangers of a lee-shore, should, it is conceived by many, be sufficient; and for these exigencies, a ship which, with four months' supplies on board, can in calm weather and smooth water make 9 or 10 knots under steam, has ample power; and it should not be forgotten that, unlike the paddle, the screw will always co-operate with sail. *If a ship would go far under steam, she must be content to go gently.*"

In the last sentence indeed lies the whole gist of the question:—

> "A ship that at the rate of 10 knots under steam may run 1200 miles, can, at the speed of 8 knots, and with the same or rather less expenditure of fuel, run a distance of 1800 miles."

From the above it will be seen that in these "Notes" auxiliary screw steamers are advocated in preference to full-powered ones, though it is confessed that for certain special purposes, such as "debarking a regiment or two of Zouaves on the shores of the Adriatic, or upon the coast of Ireland," (!) for transport, forcing blockades, &c., the latter may be found very useful on occasion. Another useful suggestion is thrown out by the author in page 49, "May not the command of a maximum speed of 13 knots be obtained from the machinery now employed for a maximum speed of 10 knots?" The means proposed are the use of artificial draught to force combustion, and of steam of higher pressure: "the inconvenience of the higher pressure with blowers could well be endured for the short and occasional periods during which they would be required." Without going into any discussion on the speed attainable, it may be laid down as an almost self-evident law, that the vessel with the higher speed will, *cæteris paribus*, have a great advantage over its antagonist; and that in forcing an entrance into a fortified harbour the chance of being struck by the batteries diminishes as the speed of the vessel increases. It should therefore be an object to obtain the greatest possible speed out of the same bulk and weight of engine; and towards this point too much attention cannot be directed.

The concluding observations of the book are on a very important subject, and might with advantage have been more extended. Recurring to an earlier page we find the following passage:—

> "The wise and liberal action of the British Admiralty, which faltered at no expense, and made trial of every improvement in machinery that gave assurance of good performance, and promised in any way the efficiency of the fleet, produced no less than fourteen distinct varieties of the screw-engine."

Whether the result of the action thus commended has been altogether satisfactory, is perhaps yet open to question; and we feel disposed to agree with the author that, "having fixed upon the proportions . . of propeller, and the plan of engine, cautious discrimination should be exercised in multiplying the types of either." It would certainly avoid an enormous amount of difficulty if certain standard forms of engines suitable to the different classes of vessels could be decided upon, and the several parts made to such specified dimensions that any portion on becoming injured could be at once replaced from the nearest depôt, or from another vessel of corresponding character. To conclude in the words of our author—

> "On the other hand, this system must not be carried to a Chinese extreme, lest we follow too long a false direction, thus losing the advantage of improvements constantly being made, for such is the change in all things pertaining to maritime war that neither model of hull, plan of engine, nor mould of ordnance is best unless of the latest creation. True progress will be most judiciously sought in not departing too suddenly and widely from the established order."

CONTINENTAL PUBLICATIONS.

Die Altchristlichen Kirschen, &c. ('The Earlier Christian Churches, after the existing remains and ancient descriptions; and the Influence of Early Christian Architecture upon the Churches of subsequent periods:' by Dr. Hübsch. Carlsruhe, folio.) This work, the author of which is an honorary and corresponding member of the Institute of British Architects, is one that will be welcome to and valued by the student of early Christian architecture. It is procurable in parts, and will be complete in ten; the cost of the whole being about six guineas. The main feature of the work is its illustrations, executed in a clear intelligible style of lithography,—geometrical drawings being in line, and views generally given in a tinted style. The ample pages are crowded by the mass of matter collected together; and few, if any, basilican churches, baptisteries, and other very ancient remains of early Christian art will be found to be absent. The tables of contents of each number give a very convenient and concise account of each building illustrated, furnishing information as to the leading dates of the different portions of its history, and thus rendering the plates of use from the first moment of getting them. The letterpress, which does not seem burdensome in amount, contains minute observations upon the buildings and features of buildings illustrated. To the archæological student this is a very valuable work, and it is full of suggestive examples for the practical architect. The text is in German.

Der Stil, &c., von Gottfried Semper ('Style in the Technical and Architectural Arts; or Practical Æsthetics: a handbook for workmen, artists, and amateurs'. Frankfort). This work, also in German, has a very ambitious scope, and the first of three intended volumes is alone before us, the subject being divided into six sections. The first section, which engrosses a whole volume, is devoted to textile art; the second, third, fourth, and fifth sections relate respectively to ceramic art, wood-work, stone-work, and metal-work, and will be included in the second volume; the subject reserved for the concluding section and volume being architecture. The aim and scope of the whole book is, to show that all the other useful and ornamental arts have exercised a traceable influence upon architecture, and to point out the nature and extent of that influence. Although the volume before us on textile art is in places prolix, and in others fanciful, and perhaps illogical, it is full of learning and information. Textile art in all periods and all nations is treated of, and illustrated by engravings on wood, and by a few plates splendidly executed in colours. Materials, modes of execution, dyes, colours, history, æsthetics, archæology, and theory are all blended, to form a volume of great extent and comprehensiveness. The leaning of the writer is evidently more towards ancient Classical art than Mediæval; and perhaps the most interesting illustrations given are those showing ancient Greek, Roman, and Pompeian specimens of coloured decoration. The investigation here undertaken of the use of carpets and hangings commonly made by the ancients, leads further perhaps than the strict limits of a treatise on textile art and its influence on the sister arts, especially architecture, seems to require, for we are landed in the study of mosaic painting, mural decoration, and the like. Those who read German, and are interested in the arts, especially in coloured decoration or decorative construction, will find this work well worth their attention.

INSTITUTION OF CIVIL ENGINEERS.

The Council have awarded the following premiums for the session 1860-61:—

1. A Telford Medal, and a Council Premium of Books, to W. H. Preece, Assoc. Inst. C.E., for his paper "On the Maintenance and Durability of Submarine Cables in Shallow Waters."
2. A Telford Medal, and the Manby Premium in Books, to G. P. Bidder, Junr., for his paper "On the National Defences."
3. A Telford Medal, to Francis Fox, M. Inst. C.E., for his paper "On the Results of Trials of Varieties of Iron Permanent Way."
4. A Council Premium of Books, to F. Braithwaite, M. Inst. C.E., for his paper "On the Rise and Fall of the River Wandle; its Springs, Tributaries, and Pollution."
5. A Council Premium of Books, to George Hurwood, M. Inst. C.E., for his Paper "On the River Orwell and the Port of Ipswich."
6. A Council Premium of Books, to William Hall, Assoc. Inst. C.E., for his paper "On the Floating Railway at the Forth and Tay Ferries."

The Council invite communications for the session 1861-62 on various subjects, for premiums. For a limited number of papers of distinguished merit, pecuniary awards will be made, not exceeding in each case 25 guineas, in addition to the honorary premiums. The following subjects have been selected as those upon which, it is hoped, such communications may be received during the ensuing session. But papers on other subjects, if of adequate merit, will be taken into consideration in the adjudication of the pecuniary awards.

On Reclaiming Land from Seas and Estuaries.

Accounts of existing Waterworks; showing the methods of supply, the distribution throughout the streets of towns, and the general practical results.

On the results of the use of Tubular Boilers, and of Steam at an increased pressure, for marine engines, noticing particularly the difference in weight and in speed, in proportion to the horse-power and tonnage.

On the Form and Materials for Floating Batteries and Iron-plated Ships ("*Frégates blindées*"), and the points requiring attention in their construction.

Railway Accidents—their causes, and means of prevention; showing the bearing which existing legislation has upon them.

The competition for premiums is not confined to members or associates of the Institution, but is equally open to all persons, whether natives or foreigners.

CHICHESTER: THE CATHEDRAL AND OTHER ANCIENT BUILDINGS.

By Gordon M. Hills.

The fall of the central tower and spire of this cathedral, which occurred on the 21st of February last, excites a general interest at this time in connection with the archæology and architecture of the city. The calamity was happily not attended with any loss of life, but is nevertheless deeply felt as inflicting a grievous loss upon the whole district and diocese.

It will assist us in appreciating the force of the calamity which has fallen upon Chichester, to take a general survey of its architectural monuments; we shall then understand how pre-eminent a feature the cathedral tower and spire formed, considered merely as a work of extraordinary architectural and archæological interest, and how greatly this pre-eminence was enhanced when to these motives were added the feelings of constant familiarity and reverence, and the ever-recurring memory of past history and association.

The general arrangement of the town as to its form can have undergone but little change, whether as the *Regnum* of the Romans, the *Cissacaester* of the second prince of the south Saxons, or the see of the Norman bishops, and city of the stern Norman Earls of Chichester and Arundel. Inclosed by ancient walls, it approaches a circular form, and is intersected by four principal streets, meeting in the centre. From time immemorial it has had without the walls the eastern suburb of St. Pancras, situated on the Roman road from London, which entered the city at that part, and the western suburban parish of St. Bartholomew. To these, in our own days, has been added the northern suburb of Somers-town.

Passing by for the present the mutilated cathedral, we are arrested in the centre of the city by the striking market-cross, erected at the intersection of the principal streets, by Bishop Story, who died in 1502. Cheddar, Salisbury, Glastonbury, and Malmesbury Crosses, though something like it in form, are very inferior to it. Winchester Cross is of another type, perhaps more delicate. The Eleanor funeral crosses are of an earlier period and more pure in detail, but none are superior in the general arrangement of the design, in fitness of purpose, and grace of outline. Except some mutilation consequent on the introduction of the clock, and the loss of its original finial, it is well preserved.

The parish churches within the city walls are those of St. Olave, St. Peter the Less, St. Martin, St. Andrew, and All Saints, which are ancient, and Sub-deanery, otherwise St. Peter the Great, which is a modern church in an ancient parish; until this church was erected and opened for service in 1850, the north transept of the cathedral had for ages been appropriated for the services of this parish. The ancient churches are all of the most simple pretensions and humble dimensions. St. Peter the Less alone is dignified with a small tower, and has one aisle to the nave. In its present neglected state its superiority to the other churches is not so apparent as from these features it should be. The other churches are mere parallelograms in plan, and for the sake of accommodation have been subject to more or less of alteration and restoration. In the most recent instance, St. Olave's, this has been done with good taste. In All Saints a handsome east window of three lancets was inserted about fifteen years ago, in the place of a rude modern one. Traces of work of the twelfth century were discoverable in the building, which led to the adoption of the style of that century for the new window. The alterations at the other churches were effected some years earlier in a style which neither needs nor merits description. At St. Andrew's, however, a mural monument, to which some interest attaches, was preserved and carefully repaired. It consists of a bust, placed in an architectural frame of wood and stone, and, from its style, is identified as the monument recorded in the parish registry to have been erected to John Cawley, who died May 3, 1621, and who was the father of William Cawley, one of the regicides. There was no inscription upon the monument at the time of its restoration (1839-40); the present inscription being due to those who interested themselves in it at that time. The churches of the suburban parishes of St. Pancras and St. Bartholomew are both modern, and quite uninteresting. The ancient churches occupied the same sites within a few feet as the modern ones, standing immediately outside of the east and west gates: they were both destroyed in the siege of the city by the Parliamentary forces in December 1642. St. Pancras was rebuilt in 1750. St. Bartholomew parish remained without a church till 1827. The modern church of Sub-deanery, to which I have before alluded, would be a respectable one for its size and architecture, if complete and more favourably placed; but standing under the shadow of the gigantic belfry-tower of the cathedral, which covers an area of ground almost equal to that of the church, it appears inconceivably dwarfed in its proportions.

St. Mary's Hospital is a remarkable building: it stands in the north-east part of the town, and consists of a large and fine chancel of the thirteenth century, with a nave of great size under a huge timber roof; with timber standards, in lieu of the ordinary stone columns, dividing off the aisles. The chancel itself is larger than any of the ancient parish churches of the city. The aisles are at present partitioned off into cabins occupied by the almsmen, and the centre part is left free. These cabins were first so arranged in the seventeenth century. The chancel is fenced off by a lofty oak screen, of very early and interesting workmanship, and has stalls corresponding in date with the screen. One other building within the walls demands notice—it is now called the Guildhall, and has been used as a court-house. It was the chapel of a Franciscan Friary, and a very fine one, of the date of 1233, the original foundation. It has five fine lancets in the east end, and good side windows, but is in a state of deplorable dilapidation.

We may conclude this portion of our subject by mentioning the modern churches of St. Paul and St. John, to which no architectural commendation can be awarded; and a small and picturesque Roman Catholic chapel.

The castle of the Norman earls stood within the city walls, near the north gate; the only mark of it remaining is the mount commonly found in the bailey of castles of this date, and now to be seen in the grounds near the Franciscan Friary. The ancient walls remain round nearly the entire circuit of the city, and were furnished with four gates, three of which were destroyed in 1772-3, and the other, the east gate, in 1783. It is pretended in Hay's History (and Dallaway's authority, which is much greater, affords some support to the notion) that some of the gates, and even the walls, exhibit Roman workmanship. I believe however that there is no foundation for this supposition. Dallaway refers to several records which show that extensive repairs and reconstructions of the walls occurred after the twelfth century. They were not probably much affected by the defences of the Royalists in 1642, as they held the city only from the 22nd of November till the 28th of December. The Parliamentary forces then proceeded to fortify the place, and held it during several years. The House of Commons, on the 2nd March, 1646, ordered the withdrawal of the garrison and demolition of the fortifications, since which the walls have been affected only by measures intended to convert them into a promenade. They undoubtedly give to the city a venerable and agreeable aspect.

Our survey thus far has discovered only three buildings which lay claim to any architectural dignity, we gladly turn therefore to the south-west quarter, where, from the earliest ages, the most imposing buildings of the city have stood. Tradition points to this quarter as the habitation of the Roman governor, and is supported by the frequent exhumation of Roman pottery (of which I speak as an eye-witness), and by the discovery of Roman coins, of which the most important find was during the works at the rebuilding of the episcopal palace, in the early part of the last century. The Roman level of the ground appears to be about 6 feet below the cathedral floor. Tradition also places here the residence of the Saxon prince Cissa, and I believe some one has been bold enough to guess at the situation of a temple of Thor, or Jupiter, in this part. When William the Conqueror transferred the see of Selsey to this city, it is certain that the bishop had the grant of this quarter for the purposes of the cathedral establishment. Stigand, the last bishop of Selsey, took the title of Bishop of Chichester in 1082. The times were however too troublous to permit either him or his successor to carry building plans into effect, and it was not till the commencement of the reign of Henry I. that Ralph, the third Bishop of Chichester, was able to make any important progress in this respect.

With the assistance and countenance of Henry I., Bishop Ralph was enabled to proceed rapidly, and in 1108 completed his cathedral. It has been erroneously supposed that this building was constructed of wood; there is no ground whatever for such a notion, beyond the fact recorded that it was burnt in 1114, by which we are to understand the destruction of the roofs and parts usually constructed of combustible material. Ralph set heartily to work to repair the disaster, and had accomplished this before his death, which occurred in 1123. To what extent the Norman portions of the cathedral we now see belong to the work of 1100 to 1108, it is difficult to say. The final destruction of the Norman piers under the tower, has proved that parts of a previous structure were built into them, even from their very base, and it may therefore be supposed that in this part at least, the destruction of the first cathedral was very complete. When finished in 1123, the cathedral had two western towers, a nave of eight bays, transepts and choir, and a low central tower, carried on four lofty arches, measuring nearly 60 feet high to the crown. The nave had an aisle on each side, as also the choir, and the latter terminated at the east end with an apse; there was a plain triforium and clerestory. Except the apse and the central parts involved in the calamity of February last, all these features may yet be seen. The eastern apse of the Norman cathedral has long been recognised beyond dispute, the commencement of the curving wall still existing on the outside of the church, with various indications that the present straight sides at the east end were a subsequent work. During the late alterations in the choir, parts of the foundations of the inner curve of the apse have also been exposed. Thus we see that the high altar of Bishop Ralph's cathedral stood just on the spot the altar has occupied down to our own day, and therefore we conclude that the main dimensions of the cathedral have never changed. About 1180 the cathedral, and almost the whole city, suffered from a destructive fire. Seffrid II., bishop of the time, vigorously proceeded to repair the damaged church, and in 1199 it was re-consecrated with splendid ceremony. He also built a palace for the bishop, cloisters for the church, and houses for the clergy. Of his palace, the only remains are the domestic chapel, a charming work, which however underwent some alteration about a century after. His cloisters do not exist, but some parts of the houses and offices still stretch along the south side of the cathedral precinct towards East-street. These buildings are interesting, though much defaced and mutilated, and used now for schools and warehouses. Seffrid's work in the cathedral can be traced with complete accuracy. The triforium remains nearly as Bishop Ralph left it, but it appears that the burning roof so injured the interior of the walls at the top, and the burning timbers when they fell so destroyed the stonework near the floor, that it was found necessary to reface with new stone the whole of the clerestory on the inside, and also the nave arches. He adapted the light mouldings and graceful forms of the Early English style, then in vogue, with great skill, to the Norman forms of Ralph's work, and profusely introduced marble columns. He also determined to add a vaulting throughout the building, and for this purpose threw some massive flying buttresses against the Norman clerestory outside, which otherwise he left with all its external Norman features, and inside he carried up slender vaulting shafts from the floor, with marble bases, capitals, and bands. It has been suggested, I know not why, that the vaulting itself was not done in his time. I see no reason to doubt that the work was followed up consecutively to its completion. It was certainly also part of his plan to abolish the apse, and add the beautiful retro-choir which we now see. It is the most graceful and charming piece of work in the whole building, and may indeed challenge comparison with anything of the period to be found in the kingdom. In execution it must have followed shortly on the rest of the work. He appears also to have contemplated the erection of a lady-chapel. I do not concur with those who discover indications of a Norman lady-chapel in the present one; it was most unusual to find one in this position at that time. To Seffrid's work belongs the upper part of the south-west tower. Seffrid's immediate successors continued his designs. In the reign of King John license was had to bring marble from Purbeck, this was between 1198 and 1207, and very possibly the material was intended for the retro-choir—where we now see that beautiful but treacherous material so extensively used.

Ralph Neville, bishop from 1222 to 1224, and Chancellor of England, temp. Henry III., built a chapel or oratory in the cathedral, and bequeathed 130 marks to the church. There can have been no respite in the works from Seffrid's time to the death of Ralph Neville. The additional chapels (which we now call aisles) on both sides of the nave, must have been added, though not all at once. Neville's chapel may have been one of those on the north side, which are rather later than the others. Coeval with this period, too, I must place the central tower, with which now Ralph's Norman piers were loaded, and from this time we must date the commencement of their ruin, arising from the imposition of a weight they were not originally designed to carry. I conceive, too, that the projector of the tower included a spire in his designs from the first moment. The architect determined not to trust to the four great Norman arches, but added immediately above them very deep and strong pointed arches; on the south side this discharging arch had a perfectly clear space between it and the Norman arch, and on the other three sides the Norman arches were nearly as completely relieved from all weight. This of course did not affect the piers or legs, which still had to carry any additional weight which might be placed above the relieving arches. I confidently believe that the spire itself was commenced before the death of Bishop Neville. The moulding on the angles cannot, I think, have originated later, but it is also highly probable that a settlement in the old Norman piers warned the architect to desist. A settlement which occurred at a very early age was distinctly marked in the junction of the south transept with the tower piers, and there were evidences of an attempt also made in remote times to readjust the work to a level line, and then of a further settlement after the adjustment.

The next work in course of time was the lady-chapel, erected by Bishop Gilbert de St. Leofard, about 1290. It exhibits a very marked advance into the Geometrical or Early Decorated period. It is vaulted throughout, and though, under the use to which it is now applied—viz. as a cathedral library, its beauty is much concealed, it is in a good state of preservation, and is a pleasing specimen of architecture. The windows are peculiar, and lose somewhat in effect from the smallness and multitude of the mouldings.

John de Langton, who became bishop in 1305, and sat till 1336, munificently added to the architectural attractions of the cathedral. The only work of his which can be strictly identified is the splendid window inserted in the old Norman wall in the end of the south transept. The chapter-house which he built is not now in existence, and the detached belfry-tower is wrongly attributed to him. It is impossible to regard the four-centred arch and square-headed door of the detached tower, and its purely Perpendicular windows, without seeing that it is impossible to ascribe them to the same period as Langton's window, the flowing tracery of which agrees perfectly with the date assigned to it in the records.

I have suggested that the construction of the spire was arrested in the thirteenth century. The architectural evidence—which I have frequently had occasion to examine personally—shows a long respite in the work above the central tower, and, indeed, a general respite for some time after Bishop Langton's death. The cathedral, minus its spire, was an imposing and nearly perfect edifice, and there were no pressing wants of accommodation to satisfy.

(To be concluded in our next.)

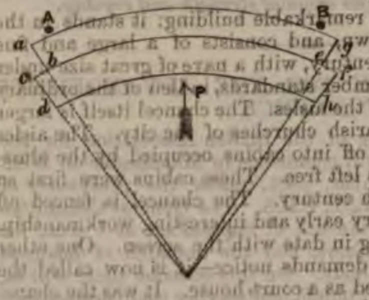
THE SHEARING STRAINS OF DEFLECTED GIRDERS.

By HOMERSHAM COX, M.A.

Of late years, the shearing strains of deflected girders, that is, the strains which result from the tendency of the particles of the beam to slide on the surface of each other, have received much attention. The object of this note is not to add anything to the mathematical theory of the subject, but to point out a simple case in which, with little aid from mathematics, the important effects of the tangential or shearing strength of beams are strikingly shown.

The ordinary theory of beams does not take into account the tangential displacement of particles, but supposes that those particles which are opposite to each other before deflection remain opposite after deflection, and that the only displacements are normal compressions and extensions. This assumption, though not absolutely correct, is sufficiently so where the transverse dimensions of the deflected beam are small compared with its length. In such cases, the tangential elastic forces of the material are generally sufficient to prevent any considerable tangential displacement. But the effect of those forces may be readily seen by the effect on the statical strength of a beam which would result from removing, artificially, part of them.

Suppose a horizontal straight beam, of which the section is rectangular, to be actually divided into two equal parts by a smooth section parallel to its upper surface; and suppose then the two parts of the beam remaining in contact to be deflected as in the diagram by a force or forces perpendicular to the surface of the beam, so that the deflections are equal at equal distances from the fulcra A and B. The diagram represents a section of the beam in the plane of deflection. The deflecting forces act on the concave surface of the beam. The section *ab* of one end of one part of the beam will not after deflection be in the same straight line with *cd*, the section of the end of the other part, as would be the case if there were no shearing strains; but *be* in the concave surface of the part of the divided beam next AB will be shorter than *cf* in the convex surface of the other part of the beam.



This may be seen very readily in the case where the deflecting pressures are such that the curves shown in the diagram are circular arcs. The neutral line of *abeg* and that of *cdhf* are both equal in length, for they are both equal to the length of the beam before deflection. But the former neutral line is the arc of a circle of a radius larger than the radius of the circle of which the latter neutral line is an arc; and therefore, since the two arcs are equal in length, but have unequal radii, the former subtends a smaller angle than the latter.

In order to estimate the loss of the strength of the beam consequent on the division along *be*, suppose only a single deflecting pressure P to act perpendicularly to the line joining A and B, the two points of support, and midway between them. Let x be the distance from B measured parallel to the straight line AB of any point in the neutral line of the beam *abeg*; and let R be the radius of curvature of the neutral line at that point; E the modulus of elasticity of the material; I the moment of inertia of the rectangular section of the beam *abeg* about an axis through its centre of gravity perpendicular to the plane of deflection. By the ordinary theory $\frac{\text{EI}}{\text{R}}$ is equal to the moment about the same axis of all the forces acting upon the part of the beam between the point in question and the nearest end of the beam. These forces are, the pressure of one of the abutments, and the pressures of the intervening part of the surface of the other beam *cdhf*. Let M represent the moment of the latter, and $\frac{1}{2}\text{P}x$ the moment of the pressure of the abutment. Then

$$\frac{\text{EI}}{\text{R}} = \tfrac{1}{2}\text{P}x - \text{M}.$$

For the beam *cdhf*, taking moments about an axis through that point of its neutral line which lies in the radius R, we have

$$\frac{\text{EI}}{\text{R}'} = \text{M},$$

where M is the same moment as before, only affected by the positive sign, and R′ is the radius of curvature of the neutral line *cdhf*. Now owing to the contact of the two beams, and their being subject to no compression in the directions of the normals to their surfaces, it may easily be seen that at the points of which R and R′ are the radii the neutral lines have a common centre of curvature, and that consequently R and R′ differ in length only by the part of R between the two neutral lines. This difference is inconsiderable compared with R. We therefore have approximately (adding the two preceding equations)

$$\frac{2\text{EI}}{\text{R}} = \tfrac{1}{2}\text{P}x.$$

If the beam were not divided into two parts in the manner supposed, we should have

$$\frac{\text{E}i}{r} = \tfrac{1}{2}\text{P}x,$$

where i is the moment of inertia of the transverse section of the undivided beam, and r the radius of curvature at the distance x from B. Now the section being rectangular, the moment of inertia varies as the cube of the distance between the convex and concave surfaces. This distance is twice as great for i as for I; consequently $i = 8\text{I}$. Therefore $\frac{1}{r} = \frac{1}{4}\,\frac{1}{\text{R}}$. It follows that the deflection produced by P will be four times as great when the beam is undivided as when the beam is divided. Assuming the ultimate strength of a beam to be proportional to the moment of inertia of its transverse section, it follows also that the breaking weight at the centre of the undivided beam is four times that at the centre of the divided beam. In other words, *the effect of dividing the beam in the manner mentioned is to reduce its strength and rigidity to one-fourth of its original strength and rigidity.*

◆

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE Thirty-first Meeting of the British Association for the Advancement of Science will commence in Manchester on Wednesday, the 4th of September, 1861, under the presidency of William Fairbairn, Esq., LL.D., F.R.S. The General Committee will meet on Wednesday, the 4th of September, at 1 p.m., for the election of sectional officers, and the despatch of business usually brought before that body. On this occasion there will be presented the report of the Council, embodying their proceedings during the past year. The General Committee will meet afterwards by adjournment. The first general meeting will be held on Wednesday, the 4th of September, at 8 p.m., when the President will deliver an address; the concluding meeting on Wednesday, the 11th of September, at 3 p.m., when the Association will be adjourned to its next place of meeting. At two evening meetings, which will take place at 8 p.m., discourses on certain branches of science will be delivered. There will also be other evening meetings, at which opportunity will be afforded for general conversation among the members.

The Committees of Sections will meet daily, from Thursday, the 5th of September, to Wednesday, the 11th of September, inclusive, at 10 a.m. precisely. The Sections will meet daily, from Thursday, the 5th of September, to Tuesday, the 10th of September, inclusive, at 11 a.m. precisely. The following are the titles of the Sections to which communications may be presented:—

Section A, Mathematics and Physics.
,, B, Chemistry and Mineralogy, including their applications to Agriculture and the Arts.
,, C, Geology.
,, D, Zoology and Botany, including Physiology. Sub-section D.
,, E, Geography and Ethnology.
,, F, Economic Science and Statistics.
,, G, Mechanical Science.

Notices of communications intended to be read to the Association, accompanied by a statement whether the author will be present or not at the meeting, may be addressed to Prof. Phillips, M.A., LL.D., F.R.S., Assistant-General Secretary, University Museum, Oxford; or to R. D. Darbishire, Esq., B.A., F.G.S., Alfred Neild, Esq., Arthur Ransome, Esq., M.A., and Prof. Roscoe, B.A., Local Secretaries, Manchester.

Gentlemen desirous of attending the meeting will find in the reception-room (The Portico, in Mosley-street) blank Forms of Proposal, and may make their choice of being proposed as Life Members, paying £10 as a composition; or Annual Subscribers, paying £1 annually and an admission-fee of £1 (making together £2 on admission); or Associates for the Meeting, paying £1. Ladies may obtain tickets, through the application of a member, in the reception-room, price £1 each ticket. These tickets are transferable to other ladies only.

◆

French Industrial Exhibitions.—Four French local exhibitions are to be held this year at Chalons-sur-Marne, Metz, Nantes, and Marseilles. An endeavour is also making in Paris to get the government to consent to the establishment of a permanent universal exhibition of commercial products. It is thought that by thus offering to purchasers from all countries the most complete and excellent collection of specimens and products for comparison, trade may be stimulated and business be drawn to France. Fixed prices attached, extensive publicity, simple and wise regulations, and great economy in the management, are held out as inducements to exhibitors.

New Hotel at Ascot.—This new building will inclose a space of two acres, forming a square, three sides of which will be occupied by stables. There will be stabling for one hundred horses, and accommodation for fifty trainers. Mr. J. E. Clark, of Newmarket, is architect and secretary to the company.

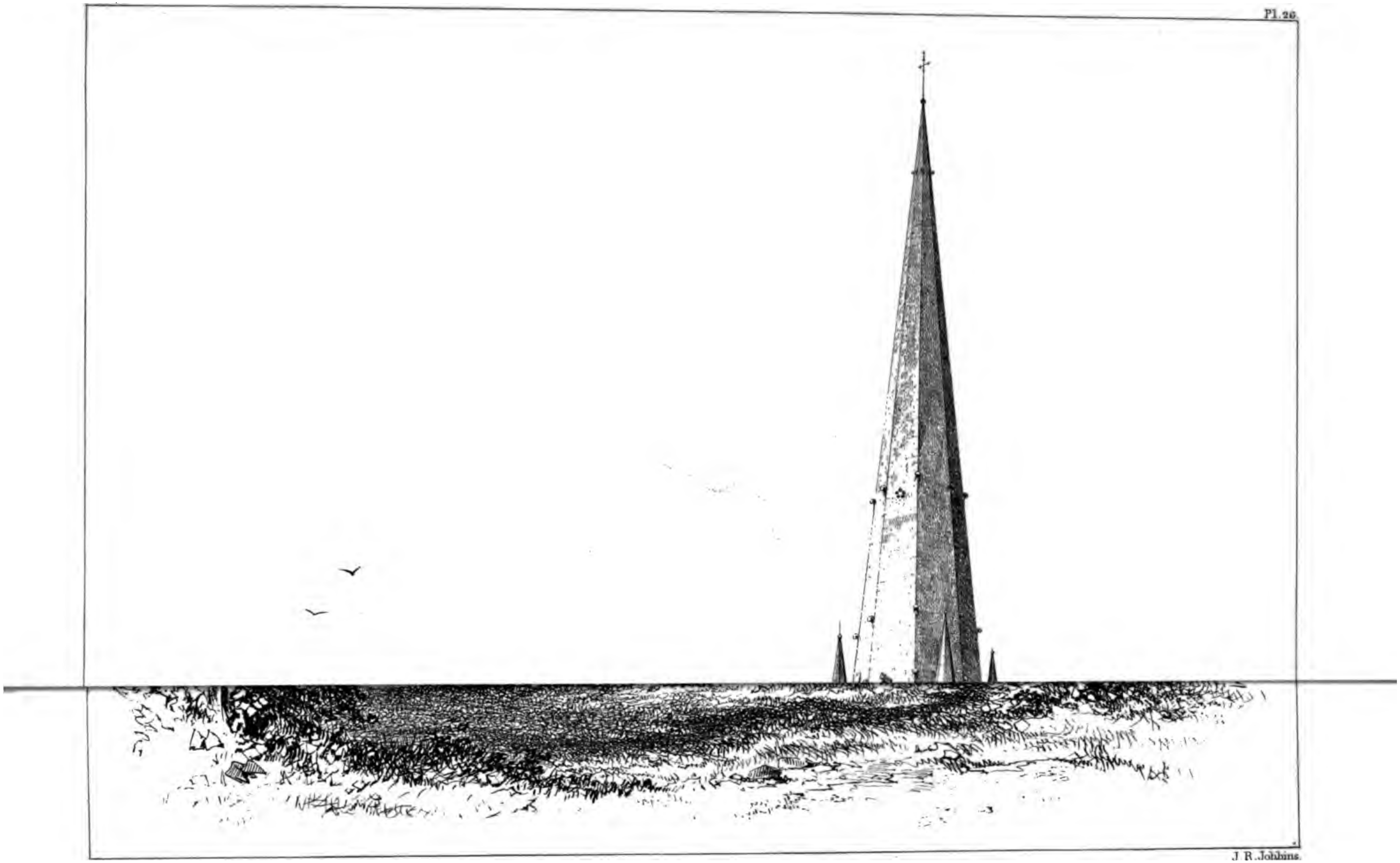
The New Vaughan Library, Harrow.—The foundation-stone of a new and important edifice, in connection with the Harrow School, was laid, on the 4th ult., by Viscount Palmerston, himself an old Harrovian. The site is immediately facing the entrance to the time-honoured school, while, on either side respectively, are the more modern school-chapel and the head-master's residence. The main purpose of the new building in question is to serve as a library for the upper boys of the school; but in addition to this, it is intended to be a general centre of school interest. It is destined for the reception of portraits, busts, &c., of distinguished Harrow men, and is intended to commemorate the head-mastership of Dr. Vaughan at Harrow, which extended over 15 years—viz. from 1845 to 1859 inclusive. A sum of nearly £5000 has been raised for the purpose by subscription, chiefly among his own pupils. The principal apartment—the library—is a parallelogram of about 70 by 28 ft., well lighted by coupled windows in each bay, and having a lofty pitched roof, which, internally, is ribbed and panelled. In the centre of the west side is the entrance porch, and in the centre of the opposite, or garden, side is a projecting octagonal bay, On this side, too, the rapid incline of the ground admits of a sub-story, which will be appropriated in various ways; and it is also proposed to add a small octagonal room, almost detached from the rest, as a kind of private room for the monitors of the school. The walling will be throughout of brick, with Bath stone dressings; and the roofs are to be covered with Staffordshire tiles. The architect is Mr. G. G. Scott, R.A., of London, and the builder; Mr. Richard Chapman, of Harrow.

The India Museum, Whitehall.—The collection of native products, and the specimens illustrative of the arts and industrial pursuits of the people of India, which for several years past had been on view at the old India House, in Leadenhall-street, have been removed to Fife House, Whitehall. The museum, newly arranged under the direction of Mr. Digby Wyatt, Dr. Forbes, and Mr. Downing, is now open to the public. A fine collection of the Elliot marbles, consisting of slabs, cornices, panels, and other portions of the sculptures from the ruins of Amrawutti, are arranged in the grounds of Fife House. These marbles have not yet been exhibited in this country; and they are remarkable for the extreme delicacy and minuteness of their finish. The subjects represented are connected with the worship of Buddha; and the marbles formed at one time portions of a magnificent temple, of which the ruins now alone remain to tell of the patient skill of its founders. A more interesting collection of sculpture does not exist; many of them are remarkable for beauty of design. There is no branch of Indian industry or of manufactures, and scarcely any description of raw produce, which is not illustrated in this interesting museum.

Exhibition of Industrial and Decorative Art in Edinburgh.—The Board of Manufactures intend to open an Exhibition of Industrial and Decorative Art on 20th Nov. next, in the National Gallery, within the suite of galleries forming the east side of that building. Mr. W. B. Johnstone has been appointed art superintendent of the exhibition.

The Archæological Institute commenced its annual summer congress at Peterborough, on the 23rd ult. The chair was taken by Lord Talbot de Malahide. The Rev. T. James, of Theddingworth, read a paper "On the Archæology of Northamptonshire;" and Mr. J. H. Parker, "On the Ancient Houses, Domestic Chapels and Hospitals in the County of Northampton and the neighbourhood of Peterborough." Mr. H. M. Bloxham also contributed an essay "On the Early Saxon Tombs in Peterborough Cathedral. On the 24th a meeting of the Historical Section took place, under the presidency of the Dean of Ely, and papers were read by the Rev. J. Earle, late Professor of Anglo-Saxon in the University of Oxford, "On the Local Nomenclature of Northamptonshire;" by Mr. C. C. Babington, Professor of Botany in the University of Cambridge, "On the Ancient History of the Fens;" and by the Rev. A. W. Brown, "On Certain Existing Landmarks of Early Ecclesiastical History." An excursion followed to Barnack, Whittering, and Caistor churches. In the evening a dinner took place at the Great Northern Hotel, and the Dean of Peterborough afterwards gave a *conversazione* at the deanery. On Thursday a trip was made to Oakham, where the castle-hall, the earthworks of the castle, the church, &c., were inspected; and at noon the party passed on to Stamford, where the various churches, the site of the Hospital of St. Thomas of Canterbury, &c., were visited.

Pl. 26.



J R. Jobbins.

Sept.r 1861

WEST FRONT OF LLANDAFF CATHEDRAL.
AS RESTORED.

Prichard & Seddon, Arch.ts

LLANDAFF CATHEDRAL.

(*With an Engraving.*)

For some years past the restoration of this greatly dilapidated ecclesiastical structure has been going on. In 1857 appeals were made to procure funds to carry on the work, which were well responded to; but though funds were obtained to carry out a large portion of the more urgently needed repairs, much has yet to be done before the cathedral will have regained its original character and beauty.

Amongst the works executed is the perfect renovation of the west front, which includes the completion of the lowest tower, and the rebuilding of the highest, with its chaste and elegant spire, the details of which will be better understood by our engraving than by description.

The once ruined section of the nave has been thoroughly restored, its arcade and its western front repaired, its clerestory and side aisles rebuilt, its walls plastered, windows glazed, and a new roof thrown over its whole span. The partition wall, which so long severed it from the portion now in use for public worship, has been removed. The roof of the side aisles of the eastern end has also been restored, with the exception of the two bays which entend beyond the chapter-house, and which are separated from the others by a small vaulted chapel. The bishop's throne is nearly completed, a portion of the stalls with the screen on one side has been erected, and contracts have been entered into for another section of the work. The progress of restoration has indeed now advanced so far, that only those who remember the ruinous state of the cathedral in former years can realise how much has been done. Of the portions untouched there still remain to be done—the reconstruction of the two bays of the roof before alluded to, the completion of the stalls with their appropriate canopies, the permanent flooring of the western portion of the nave and of the two side aisles, the repairs of the monuments, the finishing of the parapet of the southern aisle, and the provision of new doors for the two Norman doorways in the northern and southern aisles. The rebuilding of the southern tower may perhaps be looked upon as a separate work, and as one which admits of temporary delay; but it is deemed very desirable, both for the sake of appearance and for constructional reasons, that the building should be advanced another stage, so as to reach the height of the clerestory wall. The chapter-room again, which, if not an integral portion of the cathedral, stands to it in something like the relation of a transept, requires a considerable outlay, and the entire reconstruction of its windows and its roof. The cost of these two works has not yet been estimated; but it has been ascertained that to finish the roofs of the side aisles, to complete the parapet of the southern aisle, to lay the flooring, to provide doors, and to finish the stalls—all works which should be immediately undertaken, and which would, when accomplished, almost complete the work of restoration—would involve an expenditure of about £1200. An organ is being constructed by Messrs. Gray and Davidson, at a cost of £1000, which is to be used on the 17th instant, when it is intended to celebrate its erection, and the further restoration of the cathedral by a full choral service.

The whole of the works of restoration at present finished have been executed under the direction and from the skilful designs of Messrs. Prichard and Seddon, of Whitehall, London, the diocesan architects. We purpose further illustrating the restorations, and furnishing more lengthy details, on a future occasion.

THE NEW WELLINGTON COLLEGE.

This great educational establishment, intended chiefly for the sons of deceased officers who have borne commissions in her Majesty's British or Indian army, and who have been on full or half pay within five years of their death, is, according to the report just issued, in a highly thriving condition. The large and handsome building known as the College was erected specially for the purpose at a vast expense, and is appropriately named after the late illustrious commander. It was formally opened about two years back by the Prince Consort, its president, and a warm supporter from the first. A few weeks ago the same illustrious individual laid the foundation stone of a new chapel, to be attached to the general building by means of a short corridor and arcade, and thus constituting an extension eastward of the south front of the college. The style in which the latter is erected is one which its architect, Mr. Shaw, of Christ's Hospital, is thoroughly master of—the latest phase of Elizabethan, verging on the purer Classic,—but the new chapel is to be in the Ecclesiastical style, and for this special work the assistance of Mr. Scott, the eminent Gothic architect, has been secured. The chapel will measure internally about 70 feet by 26 feet, divided into five bays, each containing a two-light window with a cusped circle over, and included in a comprising arch; to divide the bays lofty pedimented buttresses are introduced, with scollop enrichment in the set-off weatherings; between these buttresses and below the windows is a simple continuous shafted arcade. The east end is semicircular, and has buttresses assimilating with those already described, the windows to the apse are single lancets, with shafted jambs. The roof is open, and supported on long corbel shafts, with carved capitals: between the two easternmost trusses of the nave rises a lofty octagonal *flèche*, or bell-turret, covered with lead, and highly ornamental in design, the spire being crocketed, and the lower portion, next the roof, richly diapered in an effective pattern. The vestry is a small apartment on the north side of the apse. The seats are all arranged longitudinally, and are five rows in depth on each side, while at the west end the back row is divided into stalls for the masters and the principal visitors.

We must take a future opportunity of describing the fittings, and the decorations and finishing generally, since these are as yet unmatured, but there is little doubt that, when completed, the chapel will be one of the most elegant and perfect specimens of its class. The execution of the work has been intrusted to Mr. G. Myers.

In the immediate proximity to the chapel it is proposed to erect a library, detached from the main building, but harmonising with it in point of design, and for which the plans have been already prepared by Mr. Shaw.

ON THE CONSTRUCTION AND ERECTION OF IRON PIERS AND SUPERSTRUCTURES, FOR RAILWAY BRIDGES IN ALLUVIAL DISTRICTS.

With Remarks upon the necessity of extended Railway Communication in the British Colonies.

By Lieut.-Col. J. P. Kennedy, late R.E.

Before discussing how countries can be best furnished with the means of intercourse essential to industry and commerce, it may be well to scan the especial bearing which that subject must have upon the constituent parts of the British Empire respectively, and in their mutual relation to each other. It may be well also to offer some estimate of the comparative degree in which our interests at home are affected by the development of wealth and activity in British Colonies as contrasted with similar developments in foreign states. The best preface therefore will be the statement of a few results and deductions, derived from some tables framed from the best authorities, to guide a true course of action and opinions in matters bearing upon these important affairs.

1. They show that the subjects of the British crown exceed 206,000,000 of souls, or about one-fifth of the population of the earth, of whom about six-sevenths are colonists.

2. That the territory under the British flag is about two and a half times the extent of Europe, sixty-three sixty-fourths being colonial.

3. That the British colonists, even in the absence of the required commercial facilities, consume half as much British produce as the remaining population of the world, although only one-fifth of their numerical amount.

4. That within the last twelve years the consumption of Britisn produce in British Colonies has trebled; whilst that of foreigh states has only doubled in the same period.

5. That the demand of the colonists as consumers is certain; whilst that of foreign states is contingent upon the ever-doubtful continuance of their friendly relations.

6. That the colonists are at all times willing to interchange produce upon the fair and equitable terms of free trade; whilst foreign states for the most part charge heavy and frequently prohibitory duties.

7. That the British East Indian territories, from the past neglect of their industrial development, up to the year 1855, only

consumed British produce to the value of 1*s.* 2*d.* per head of population: whilst British Australia consumed £8. 12*s.* 8*d.* per head; British America, £1. 8*s.* 3*d.* per head; the British Mediterranean possessions, £4. 5*s.* 8*d.* per head; and the British African Empire, £2. 1*s.* 2*d.* per head, of their respective populations.

8. That the results of coeval conquests, by the plough in America and the sword in India, offer a most significant contrast for the edification of statesmen (up to the year 1848) by showing that, within two centuries and a half, the first few British settlers in a Virginian wilderness had expanded into a mighty empire, with a population of 18 millions of souls, and consuming the annual value of £9,500,000 of British produce; whilst India, with her ready-made population of 170 millions, her ancient cities, her fertile lands, and her infinitely varied powers of production—powers of course dormant as long as the means were withheld of conveying produce to markets;—this India, under the government of a British mercantile company, could only consume value for £4,500,000 sterling of British produce.

9. That in 1848 the United States of America exhibited 5682 miles of railway under traffic, with 12,000 miles in rapid progress, in addition to an extensive natural and artificial means of water communication; whilst India remained *in statu quo*, without a single mile of railway.

10. That the wages of labour—that sure indication of a nation's condition—had reached in America (1848) 4*s.* per day; whilst in India it remained at its old rate of 3*d.*!

11. That in 1849 Indian lethargy yielded—railways were commenced; more active measures of improvement have been responded to by Indian industry, and the consumption of British produce has increased from £4,551,449 in 1848, to £9,949,154 in 1855, and to £19,844,920 in 1859.

12. That the value of India to Great Britain has quadrupled within the last eleven years, and even doubled within the four years ending 1859, although those four years included the period of the mutiny, with all its deranging effects upon commerce.

13. That the Indian demand for British produce taken at 1*s.* 2*d.* per head of the population in 1855, increased to 2*s.* 3*d.* per head in 1859, and amounting to £2,500,000 sterling of increase per annum, would if the same rates of increase continue, in about ten years make Indian consumption equal to the present consumption of all the British Colonies, including India. In about twenty-five years it would exceed the present demand from all foreign states; and in forty-four years it would be equal to the present demand from all foreign states and British Colonies taken together; and that even in the last case the consumption of British produce by the Indian people, would not exceed about 15*s.* per head, or between one-fifth and one-sixth of the present demand per head from the Mediterranean Colonies, and one-eleventh of the demand from the Australian Colonies.

14. That taking the present yearly increasing demand of India for British produce at £2,500,000 sterling, and the aggregate yearly increase of all the other Colonies about the same amount, making the total yearly increasing demand for colonial consumption about £5,000,000; then this rate of increase continued for seventeen years, would make the yearly demand from British Colonies alone, equal to the entire of the present exports. Such progress, however, must distinctly depend on the due supply of those facilities for transport, which are indispensable; and, so far as India is concerned, the total absence of the principle of self-management renders that supply entirely dependent upon the action of the British Government.

15. The fore-knowledge of these subjects demands the attention of every class in the state: it especially concerns the engineers of Great Britain, who besides being the pioneers of industry, wealth, and civilisation throughout the world, hold undisputed possession of the inalienable staple trade of England, and actually send forth in the aggregate one-sixth of the entire British exports.

16. It in a higher degree still concerns all those engaged in the cotton trade, who receive about one-sixth of the total imports, and contribute from half to one-third of the exports, and whose supply of cotton wool, now so seriously threatened owing to its dependence upon a convulsed foreign state, can only be rendered certain for the future by extending its growth and its means of transit in India and other British territories.

17. The subject of colonial development is not only interesting to the cool judgment of the statesman, the speculator, the economist; but to the warm heart of the philanthropist and the Christian, as affording an easy approach to a safe asylum, instead of a rugged trackless passage to a rude wilderness, for the reception of those that are forced by the crowded condition and competition of England to abandon their native homes.

18. In this also we shall find the most fitting remedy against the most dangerous of all the indications that threaten our progress, trade combinations and strikes! It will sustain the rational law which should regulate supply and demand; and people will be satisfied to go, when they can go with comfort and certainty, from a glutted labour market to where they are wanted—instead of undertaking the impossible task of forcing a fictitious rate of wages destructive to their own trade.

19. This is a portentous subject, considering that the population at home are now increasing at a yearly accelerating ratio which has already reached one-third of a million per annum, whilst emigration for the last fifteen years has averaged over a quarter of a million per annum. The mutual and the highest interests of Great Britain and her Colonies require—that associations be formed in every county and borough, to promote those facilities that are essential to colonial wealth, and its exchange for British produce. The cotton interests have made a slight move in this direction; but that movement should be general in its object, and universal in its action. If it were so, we should not see the representatives of counties and boroughs neglect their most important duties, by deserting the House of Commons the moment a colonial question is introduced. What comparative benefit can be derived from the discussion of local home questions, where everything already exists that can facilitate industry, civilisation, enjoyment, and free action; whilst to supply the only real want—an increase of colonial customers—is within the power of parliamentary action, but unmeaningly withheld.

This is not merely a question of national wealth: it is a question of national conscience. There are fifty-three distinct British states, of which thirty-six, numbering 34 millions of people, are governed by their own representatives, and therefore for each of these their respective parliaments are responsible: whilst from the remaining seventeen states, numbering 172 millions, the power of self-government has been, no doubt wisely, withheld by the British parliament, but so long as it is withheld the British members of parliament are as responsible individually for those 172 millions, as if they formed a portion of the constituency of each British county and borough. The latter class of Colonies includes British India, numbering alone 171 millions, possessing a large state revenue, which ere this, and without taxation, would probably have far exceeded that of England, had those indispensable facilities to industry been furnished to India which it is the duty and the practice of every civilised government to provide for its subjects. But they were unmeaningly withheld; and therefore are Indian customers scarce, Indian lands untilled, Indian minerals unsought, Indian wages 3*d.* per day.

This state of things requires a change, not only as regards the wealth, but the honour and character of England. The past government of India must be measured by the American scale. What has been done in the West might have been done in the East. The United States, for a population of 30 millions, have opened 31,000 miles of railway intercourse, with 16,000 miles more in rapid progress of construction. They have been rich and prosperous, because their industry had free scope. British India, with a population of 171 millions, has opened but 1100 miles of railway, with but 3600 more in progress of construction. Her people are poor and famine-stricken, because their industry has not had free scope.

The earnest desire of the present British and Indian administration to open the means of intercourse through that vast empire is undoubted. They have done much: they are doing much. But they are not doing enough—much more is required. There is no time for delay, and their efforts demand a comprehensive support and impulse from the British parliament. Their task is not merely that of stimulating improvement in a natural way, as in states that have been keeping pace with the ongoing of the world. The present Indian government have to make up for 100 years' negligence of their predecessors; and the arrears of those progressive operations that ought to have been effected from year to year out of moderate annual grants, are now accumulated on the heads of the ministers in power. Who can foresee the evil effects of the present insane American conflict upon British trade and manufactures? The prime source of our raw material is threatened;—the first consumer of our manufactured produce may be withdrawn. The crisis is most imminent, and can only be alleviated by redoubled exertions in India, which can rapidly, if fostered, supply the threatened deficiencies, by the consumption of a sevenfold population as to our manufactured produce, and by an inexhaustible soil capable of yielding every variety of raw produce to feed our manufactures. But to bring this about will require an exertion beyond the reach of the government, unless sustained and impelled by the parliament; beyond the power of the parliament, unless sustained and impelled by the people of England. These respective impulses must be based upon a thorough understanding of the object to be attained; and therefore it behoves every thinking man in England to study these grave questions: it behoves every county and every borough to form an association, which shall stimulate their representatives to perform their duties in respect to British Colonies that do not possess local representative governments.

Having thus considered hastily a few of the broad objects to be kept in view, we may now proceed to the practical discussion of the first and most essential approach to their accomplishment, by examining how the opening of communication may be most rapidly and economically effected. This important subject shall be illustrated by certain operations now in progress in India.

In undertaking a system of railways and means of intercourse essential for the development of industry in any country, the first consideration should be given to the character of the piers and superstructures of the bridges. In India these form a large proportion of the works of a railway; and the piers especially in alluvial districts have a particular bearing upon the absolute practicability, and the cost and consequent success, of such undertakings.

A good illustration of this important subject is afforded by the works completed and in progress in the construction of the Bombay and Baroda Railway in India, with which the writer is connected; where a special construction has been adopted for the bridge piers and superstructures, in order to meet the difficulties of the alluvial districts through which the railway passes, and to attain a facility and rapidity of erection combined with economy in total cost. Most of the Indian railways should take their course through such alluvial plains and valleys, where there is only one important natural impediment to their construction, consisting in the bridging of the rivers, many of which are crossed within tidal influence: and all of them are swept by fierce monsoon currents, while their beds in general offer the worst foundations for the construction of masonry piers. They thus combine the greatest impediments to the erection of the usual description of bridges. The great cost of erecting a bridge acoss the Thames in London is generally known; and yet in that case there are the best engineering talent, and the greatest mechanical aid, immediately within reach; and although the natural impediments are of the same class, they are far inferior in degree to those met with in Indian rivers. The line of country traversed by the Baroda Railway in its level course of 313 miles from Bombay to Amedabad, is more intersected by rivers of the above character than any other railway in India. So vast did the difficulties appear, that the very practicability of constructing the line was seriously disputed; and not without reason, if it were assumed that the bridge piers must be executed upon the old stereotyped masonry plan, and that the engineer would not adopt those modern and well-tested improvements that were applicable to the case. To those however who knew the precise nature of the local difficulties, as well as all the modern engineering improvements by which they could be surmounted, it was clear that this line could be effectually and economically executed, provided such modern improvements were applied; but by no other means could a maximum financial return for the outlay (which ought to be the first principle in engineering) be secured.

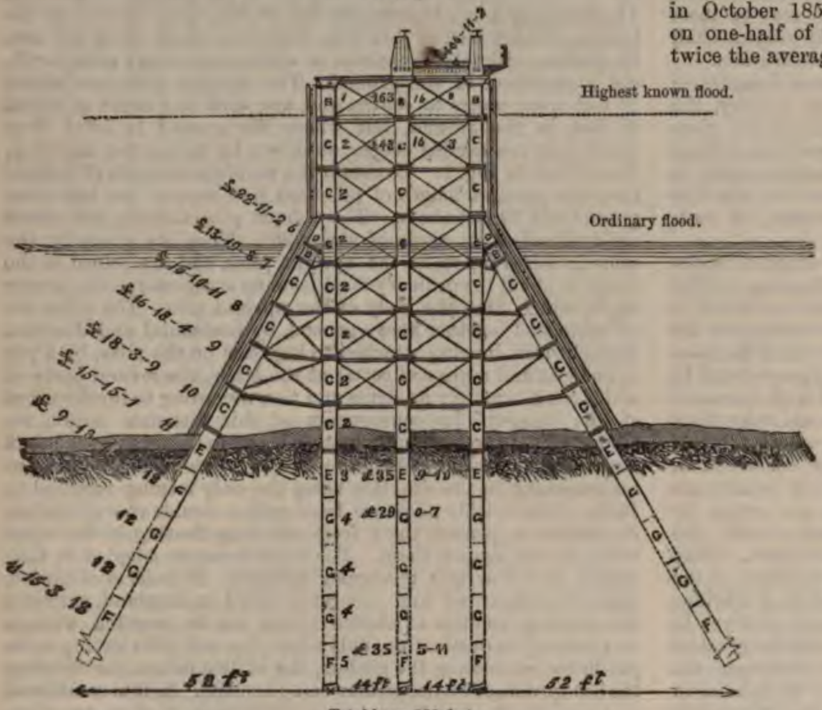
The object was therefore to show that it was practicable to overcome with rapidity and economy the great characteristic difficulty opposing the construction of Indian railways, even where most prominently encountered. The writer accordingly proceeded to ascertain, first, all the engineering and financial requirements, and to investigate the comparative merits of all well-tested improvements calculated to meet them; whence it was ultimately concluded that to bridge Indian rivers in alluvial districts on the old principle of masonry or brickwork would be both tedious and ruinous to the undertaking; but that the most difficult rivers so situated may be economically bridged by adopting wrought or cast iron for the piers, and wrought-iron in the superstructures. The writer finally arrived at one pattern of bridge, admitting of extension or contraction to meet all the variations of circumstances that occur in such cases, as to height or length of bridge, and depth and nature of foundations.

Fig. 1 shows the construction of piers adopted in strong tidal rivers, such as the Taptee and Nerbudda, where the depth of floods reaches from 40 to 60 feet, with a velocity of 6 to 10 miles per hour; and the force of the current acting alternately in opposite directions on the piers, requires the addition of oblique piles to act as struts on both sides of the pier. The piers are composed of hollow cylindrical cast-iron piles, of 1-inch thickness of metal and 2 ft. 6 in. outside diameter, cast in 9-feet lengths weighing 1½ ton each. They are of two principle patterns for the portions of the piles above and below the ground. Those above the ground have flanges outside for bolting them together by twelve 1-inch bolts; while those underground have the flanges inside bolted together by ten 1-inch bolts, and are flush on the outside, so as to offer no resistance in penetrating the ground; they are large enough inside to leave room for a man getting in to bolt the several lengths together properly in the process of erecting. The foundation is obtained by one of Mitchell's screws at the bottom of each pile, of 4 ft. 6 in. diameter, which finds its own foundation without the expense of cofferdams or any other artificial preparation of the ground. The upright piles are placed 14 feet apart centre to centre, and are sunk to a depth of about 20 feet in the ground, but where the ground is softer than usual they are carried deeper, as shown by the portion drawn in dotted lines in Fig. 1. To obtain the requisite strength of foundation, the greatest length of pile used has been 45 feet below the ground and 72 feet above. The oblique piles forming the struts are inclined at an angle of about 30°. They are precisely the same in construction as the upright piles, and are joined to the latter at about the ordinary flood level by a cap cast at the proper angle, which clips the body of the upright pile. The piles are all connected together above ground by horizontal and diagonal wrought-iron bracing attached to lugs cast on the piles, by a pin at one end and a gib and cottar at the other, the several parts of which act alternately as struts and ties, according to the direction of the current. In consequence of this alternate strain, an accurate fit of the bracing is required, and to insure this the joints at one end of each are therefore left to be done in India, from measurement on the site, this being the only forging required in India. The outside piles are faced with a double row of timber, as a fender, to protect them from anything floating in the water being carried against them. The superstructure adopted is that known as "Warren's triangular system." This form of girder, when manufactured and accurately fitted in England, requires the smallest amount of skilled labour for its erection abroad, on reaching its destination; only a few pins and bolts having to be put in for completing the girders, the skilled labour for riveting the box girders or lattice girders being avoided. As it is considered that uniformity of parts, as far as practicable, is of as great importance in bridge work as in other mechanical structures, a uniform span of 60 feet is adopted for all the iron bridges on the line, this being considered the most economical, having reference to the general heights of the piers. One end of each girder is fixed on the pier, while the other end is carried on a pair of small rollers, to allow of expansion and contraction. The weight of the entire 60 feet superstructure for a single line of rails is 24 tons, being 8 cwt. per foot run; and the cost at the present rate of iron is about £400. The weight of a single complete pier of five piles, for two lines of rails, 63 feet high from the foundation, is 75½ tons, and the cost £624 delivered in London.

In the construction of piers adapted for inland rivers with deep water, say 20 to 50 feet, but not tidal, where the current is always in one direction, the oblique piles acting as struts are required only on the lower side of the bridge, and the timber fenders only on the upper side. Fig 2, shows the piers for inland rivers with shallow water of not more than 20 feet depth, where the oblique piles can be dispensed with altogether; and where there is a rock foundation the screws are omitted, and the piles are simply let into the rock about 2 feet, and filled round with cement, allowing of great rapidity of erection in this case. In some situations the rails are carried at the level of the top of the girders to obtain the advantage of the additional height, instead of being supported from the lower edge of the girders; and the girders are then braced with diagonal ties to give increased stability under the load.

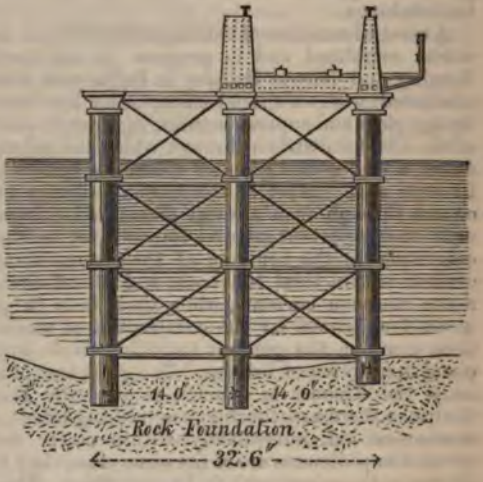
A valuable proof of the strength of the piers erected in the manner above described was afforded by the exposure of the Nerbudda viaduct on the Baroda line to the monsoon of 1860, whilst still in an incomplete state, the works having been suddenly stopped by the cholera breaking out among the men. There were at the time only two piles erected at the last pier, which reached into the middle of the stream, without any oblique piles to serve as struts in supporting it; but the pier resisted the deepest and fiercest current of the river without sustaining any injury. At this bridge greater rapidity in screwing down the pile piers was latterly attained by Mr. Forde's application of animal power direct at the extremities of 40-feet levers made fast to the piles, without the intervention of crab winches or other multiplying wheels. Four of these levers, with eight bullocks yoked to each, were applied to screw every pile. This plan would be applicable to all pier sites not permanently covered with water. When any considerable depth of water exists the practice hitherto has been to erect a temporary staging or platform upon timber piles, from which the permanent iron piles are screwed down by a lever and capstan worked by men, but probably a more economical mode would be to use a floating stage carried upon well-anchored pontoons. The principal element of strength in these bridge piers is the firm and accurate fixing of the horizontal and diagonal bracings between the piles from the bed of the river upwards. This and other necessary operations in deep water are effected by submarine fitters, furnished with Heinke's diving helmet and dresses, which are indispensable in such cases.

Fig. 1.



Total base, 132 feet.

Fig. 2.



Previous to adopting the "Warren" system for the bridge superstructure, the writer tested a girder of this construction, of sixty feet span, to the breaking point, and finding the results generally satisfactory, strengthened the parts very considerably in the subsequent designs, rejecting all cast-iron, and increasing the quantity of wrought-iron beyond previous practice. An additional strength is thereby attained which has already proved of great service, having enabled the Wiswamuntree bridge to resist successfully the shock to which it was exposed by an accident, arising from a malicious plot for destroying the train, on the 17th of January, 1861; the train was thrown off the line by a rail placed across, and broke some of the cross girders supporting the track; but it was completely held up by the main girders, and the bridge sustained no further injury from the accident. The regular test to which the superstructures have been submitted in England was 2 tons per foot run, or about double the maximum load that can be placed upon them in practice. This test load was rolled on in trucks from a siding; it caused a deflection of only five-eighths of an inch in the centre of each 60-feet span, and upon removing the load the girders recovered their original camber, without taking any permanent set. The greatest strain to which any portion of the girders is subjected under the heaviest practical load is 3¾ tons per square inch of section.

The piers and superstructures from ninety-five bridges on this plan of construction have now been sent to India, comprising 477 spans, and making about 6 miles of viaduct upon the Baroda Railway; and the trains on the 139 miles opened within the last year pass over thirty-three bridges, comprising 215 spans of 60 feet each. There has not been a single failure in the foundations with the iron-pile piers, though nearly all the foundations were bad; whilst the attempt to erect masonry abutments even for 10 and 20 feet spans has failed in several instances in similar localities.

The rapidity of erection afforded by this mode of construction is well illustrated by the progress made on the second or central division of the Baroda Railway, extending over a length of 80 miles, and including the most difficult part of the entire line. Possession of the land for this portion of the line was obtained in October 1858. The average amount of iron-bridge viaduct on one-half of this division, including that of the Taptee, was twice the average of the whole; for about 40 miles in this locality, or one-eighth of the entire line, included one-quarter of the total amount of bridge work. The Taptee bridge, 1891 feet long, spanning a tidal river, and erected on an alluvial bed, was opened for the passage of trains in November 1860, within one year from the sinking of the first pile; this great work ranks the second in point of difficulty on the entire line. These 40 miles of railway just completed, including eighteen iron bridges, making up more than 1½ mile of viaduct, have occupied only about two years and a half in the construction—forming a remarkable achievement in railway operations. These works being the first of the description executed upon a large scale, the writer was not able to meet with engineers experienced in the erection of this particular class of bridge work. Only one of the engineers on the line had previously erected a Warren girder, and only one had previously sunk a screw pile. None of the others had previously erected either piers or superstructure of this class: yet in this their first effort in the erection of railway bridges upon iron screw piles their success was as above stated; and with their increased experience they can now erect as many piers at a time as it might be found admissible to carry on simultaneously, each being completed in a fortnight; and could cover the piers with their superstructures at the rate of one span in every two days. This rate of erection was nearly attained in practice in the construction of the division of the line above referred to.

An important essential to economy and rapidity of construction is to provide beforehand a large proportion of the permanent way and bridge materials, and to have both of them in readiness at the proper commencing point of the line, before the earthworks are undertaken. This precaution would add to the economy of

General Tabular Scale for calculating Composition and Cost of Bridge Piers,

The superstructures being constant quantities for spans of 60 feet—viz. 1st track, 24 tons of wrought-iron at £16. 16*s.* per ton, £406. 11*s.* 2*d.*; 2nd track, 22 tons 14 cwt. at same rate, £380. 17*s.* 2*d.*—delivered in London.

Description.		Ton	cwt.	qr.	lb	Cost delivered in London.
CLASS I.						
3 Pile caps (A,—see Fig. 1) ...	(Cast)	2	12	3	14	
3 Piles (B)	do.	3	19	3	14	
Total cast-iron (carried down)		6	12	3	0	£49 15 7
2 Horizontal T iron struts, ...	(Wrought)		3	3	24	
4 Diagonal L iron bracings ...	do.		6	2	20	
3 L iron rings	do.		3	2	22	
54 Bolts, nuts, and washers, 1"×4½"	do.		1	0	6	
4 Ditto ditto, 1½×7½"	do.		0	1	3	
4 Gibs and cottars	do.		0	0	17	
Total wrought-iron			15	3	8	14 0 8
Total		7	8	2	8	£63 16 3
CLASS II.						
3 Piles (C)	(Cast)	4	8	2	9	33 4 4
2 Horizontal T iron bracings ...	(Wrought)		4	0	6	
4 Diagonal L iron bracings ..	do.		6	3	0	
36 Bolts, nuts, and washers, 1"×4½"	do.		0	2	22	
4 Ditto ditto 1½"×7½"	do.		0	1	3	
4 Gibs and cottars	do.		0	0	17	
Total wrought-iron			11	3	20	10 11 11
Total		5	0	2	1	£43 16 3
CLASS III.						
3 Piles (E)	(Cast)	4	3	0	7	31 2 11
2 Horizontal T iron bracings ...	(Wrought)		4	0	6	
30 Bolts, nuts, and washers, 1"×4½"	do.		0	2	9	
4 Ditto ditto 1½"×6½	do.		0	1	2	
Total wrought-iron			4	3	17	4 6 11
Total		4	7	3	24	£35 9 10
CLASS IV.						
3 Piles (G)	(Cast)	3	16	0	5	28 10 4
30 Bolts, nuts, & washers, 1"×4½"	(Wrought)		0	2	9	0 10 3
Total		3	16	2	14	£29 0 7
CLASS V.						
3 Piles (F)—screw	(Cast)	4	14	0	14	£35 5 11
CLASS VI.						
1 Pile (D)	(Cast)	1	9	1	0	
1 Pile (B)	do.	1	6	2	14	
Total cast-iron		2	15	3	14	20 19 0
30 Bolts, nuts, & washers, 1"×4½"	(Wrought)		0	2	9	
1 L iron ring	do.		1	0	26	
Total wrought-iron			1	3	7	1 12 2
Total		2	17	2	21	£22 11 2
CLASS VII.						
1 Pile (C)	(Cast)	1	9	2	3	£11 1 5
1 Horizontal T iron bracing ...	(Wrought)		0	2	16	
1 Diagonal L iron bracing ...	do.		1	1	20	
1 Ditto	do.		0	3	26	
12 Bolts, nuts, and washers, 1"×4½"	do.		0	0	26	
Total wrought-iron			3	1	4	2 18 3
Total		1	12	3	7	£13 19 8
CLASS VIII.						
1 Pile (C)	(Cast)	1	9	2	3	11 1 5
1 Horizontal T iron bracing ...	(Wrought)		1	1	26	
1 Diagonal L iron bracing ...	do.		1	3	12	
1 Ditto	do.		1	1	25	
12 Bolts, nuts, and washers, 1"×4½"	do.		0	0	26	
Total wrought-iron			5	0	5	4 9 6
Total		1	14	2	8	£15 10 11
CLASS IX.						
1 Pile (C)	(Cast)	1	9	2	3	11 1 5
1 Horizontal T iron bracing ...	(Wrought)		2	1	0	
1 Diagonal L iron bracing ...	do.		1	3	26	
1 Ditto	do.		2	0	14	
12 Bolts, nuts, and washers, 1"×4½"	do.		0	0	26	
Total wrought-iron			6	2	10	5 16 11
Total		1	16	0	13	£16 18 4
CLASS X.						
1 Pile (C)	(Cast)	1	9	2	3	11 1 5
1 Horizontal T iron bracing ...	(Wrought)		4	0	18	
1 Diagonal L iron bracing ...	do.		2	1	24	
1 Ditto	do.		1	0	18	
12 Bolts, nuts, and washers, 1"×4½"	do.		0	0	26	
Total wrought-iron			8	0	2	7 2 4
Total		1	17	2	5	£18 3 9
CLASS XI.						
1 Pile (E)	(Cast)	1	7	2	21	10 7 8
1 Horizontal T iron bracing ...	(Wrought)		5	2	17	
10 Bolts, nuts, and washers, 1"×4½"	do.		0	0	22	
2 Ditto ditto 1½"×6½"	do.		0	0	15	
Total wrought-iron			5	3	26	5 7 5
Total		1	13	2	19	£15 15 1
CLASS XII.						
1 Pile (G)	(Cast)	1	5	1	11	9 9 9
10 Bolts, nuts, & washers, 1"×4½"	(Wrought)		0	0	22	0 3 4
Total		1	5	2	5	£9 13 1
CLASS XIII.						
1 Pile (F)	(Cast)	1	11	1	14	£11 15 3

NOTE.—In the above table the cost of cast-iron is reckoned at £7. 10*s.* per ton, and of wrought-iron at £17. 15*s.*—delivered in London.

the results by enabling the materials to be carried forward to their intended sites along the railway itself, as soon as the rails were laid on formation level; and would admit of rapid ballasting as soon as the earthworks had received their first rains or monsoon seasoning. It would besides have a beneficial effect in consolidating the banks, by the transit of heavy loads prior to the ballasting, and before opening the line for traffic. In order to secure the greatest regularity in the supply of the materials in India, all the portions of each pier and each span of superstructure should be shipped together in the same vessel.

The system of construction now described aims at maintaining the greatest practicable uniformity of parts, and the smallest variety, with the greatest durability of pattern, throughout all branches of the railway works. This can only be secured by well considered designs based upon strict tests. The first templates should be the best fitted to their object of any at the time in existence, and should be preserved until some indisputable improvement required a change. The greatest judicious uniformity of parts and designs is essential to the greatest attainable economy, rapidity, and certainty, both in construction and after-working.

On this railway precise uniformity has been established between the corresponding parts of every pier and of every girder in the ninety-five iron bridges. Without such uniformity it would have been impossible to secure either precision of manufacture at home, rapidity of erection abroad, or freedom from the cost, inconvenience, and delay which must attend losses at sea, when each work is upon a special and separate design. In erecting the work each engineer, artificer, and labourer becomes rapidly accustomed to his particular part of the work, and acquires increased expertness. The work at one point being completed, the men are moved forward to perform similar operations elsewhere with similar materials. What has been aimed at in this respect is, to apply to the construction of great public works the principle of manufacturing success—namely, repetition of the same operations throughout.

From the present state of iron structures of this class that have been standing for many years, and have been well taken care of, their probable duration for a hundred years may be inferred, which would bring them to between the ages of the old Westminster and Blackfriars masonry bridges; the former of these has for the last six years been in process of rebuilding, and the latter is awaiting a similar renovation. After three years' use of the Baroda Railway iron bridges, a comparison of their cost with that of the old Westminster masonry bridge, would show that their entire outlay would in that time be refunded. These are strong grounds for the use of iron bridges, even in the absence of effectual precautions against oxidation. At the same time, the discovery of some such effectual precaution is unquestionably the most important desideratum within the range of the engineering profession, with a view to further increasing the durability of iron structures.

The cost of the entire construction of the line may amount to about £10,000 per mile, but had the ordinary method of constructing the bridges been adopted, even if practicable by that course, the cost must have reached from £16,000 to £18,000 per mile.

In connection with the railways now in progress in India as main trunks, and considering that the country is at present absolutely without secondary roads converging to them, it becomes a very important question, what is the most profitable description of secondary roads to adopt; and that plan will be best which enables goods to be conveyed most cheaply, taking into account first cost, maintenance, and working cost. Comparing an ordinary metalled road with a light tramway capable of being worked by animal power or a small locomotive-engine, the construction, cost, and the maintenance of the tramway may be assumed at double the amount per mile of the ordinary road, but the tractive effect of the same power on the tramway would be eight times that on the road, and the effect of gradients will be the same on each. Comparing steam-power with animal-power for cost of traction, the former may be taken, after leaving a large margin, at half the cost with four times the speed; and it may therefore be considered that the total cost of haulage by steam-power on a tramway is one-half that of animal-power on a tramway, or one-fourth that of animal-power on ordinary roads.

It is a very satisfactory circumstance, that one native Indian Prince, the Guicowar of Baroda has already set the example of constructing from state funds a tram-road converging to a trunk railway, having commenced one of 20 miles length through a rich district, from Dubboee to the Meagaum station on the Baroda line, which is to be opened as a horse tram-road before the next cotton season. Mr. Forde, the late chief engineer on the Baroda line, has undertaken the construction of this tram-road at a cost of £1300 per mile, using rails 12 lb. per yard, and a 2 ft. 6 in. guage. In the writer's opinion both the guage of a tram-road and the weight of rail ought to be considerably increased beyond those dimentions; the guage to, be say 3 ft. 6 in., and the rail 28 lb. per yard at least. The question of the introduction of a minor class of railway or tram-road is one of much importance, requiring the forethought and distinct arrangement of the government; as it is really as essential that a uniform guage of road, height and guage of buffers, and clearance guage, &c., should be established for such minor roads, as for the main trunk lines, otherwise there must be endless and costly trans-shipments as the system becomes developed.

It may be observed with reference to the extension of railway communication, that with good working arrangements the Indian railway companies will find themselves in a most favourable position to carry out their task with every element that can secure the most satisfactory results. Taking the particular line under review as a sample: it traverses a vast, populous, and most productive district;—its ruling gradient is 1 in 500;—its cost of construction, about £10,000 per mile, or one-fifth of the rate of much easier lines executed in England;—it is protected by the establishment of a moderate rate of train speed;—its locomotive superintendence and maintenance of way are under one undivided responsible control. Such combined elements must insure safe travelling at low fares for the public, together with a liberal remuneration to the shareholders; and thus tend to restore the confidence of capitalists in similar beneficent operations so essential to the progress of the British Empire, both home and colonial.

NOTE.—When describing the superstructure of these bridges, it should have been mentioned that the position of the roadway may be regulated either by placing the cross girders which carry the roadway above the compressive beams of the main girders, or upon brackets fixed to the main piers of the lower tension bars. The upper position for the roadway is preferable, because it combines the effect of both main girders to resist forces tending to produce the buckling of the compressive beams. The upper or lower position of the roadway in this respect must be decided by the amount of headway under the bridge, or the clearance between the bridge superstructure and the highest known flood-level of the stream: there should not be less than 5 feet. The power to resist buckling must be made ample, whichever position is given to the roadway. In every case there must be a horizontal diagonal bracing between the cross girders carrying the roadway, continued from pier to pier; and where the roadway is on the top of the main girders there should be additional oblique stays from each of the cross girders, to points near the lower main pins of the horizontal tension bars. All these precautions are essential to secure the requisite stability and freedom from vibration in the roadway and girders.

(To be concluded in our next.)

THE LATE RESTORATIONS AT ST. ALBAN'S ABBEY.

AT the commencement of these works in September 1860, the walls of the north aisle, the north transept, and the north choir, were buried to a considerable height above the original ground level by the accumulation of earth; in consequence of which they were constantly damp, and the effects of this were visible in the interior, particularly in the north transept, where the ground rose to a height of about 10 feet above the floor line. In addition to this, the drainage was very defective, and the rain-water which fell from the roofs increased the dampness of the walls. At first permission was obtained from the then owner of the land to remove the soil for a little distance back from the walls, along their whole length; and shortly after this the committee were enabled to purchase the whole of the land adjoining the north side of the abbey, and extensive excavations were then made, so as thoroughly to open out the walls down to the original level, and to shape the ground into agreeable forms. By this means the great source of the dampness of the walls was removed, and the appearance of the north side of the abbey materially improved. Proper drains are now formed also along the north side of the church, by which the water from the roofs is carried off, and the ground at the foot of the walls has been paved, to thrown off wet from the foundations. In addition to this, considerable expense was incurred in repairing and diverting other drains which ran under this piece of ground.

The parts of the walls thus exposed to view were carefully repaired, and the foundations underpinned wherever they were found to be decayed. The walls along the whole north side were thoroughly repaired, and the defective parts of the buttresses towards the west end renewed. During these operations some very curious details were found built up in the aisle walls, towards the west end. They consisted of the remains of some exceedingly fine tabernacle work, retaining its ancient colouring as fresh as when originally done. These are now placed in the north-west porch. There were also found proofs of a chapel having existed against the aisle in this part, the respond of the arch remaining embedded in the wall; this has been built up, but in such a manner that it can be easily opened out for examination. In the north side of the transept there was discovered a very singular domed chamber, constructed in the thickness of the wall.

At the eastern end, the buttress of the choir-aisle (which stands within the newly-purchased ground, and which was giving way) has been thoroughly restored, the base mouldings renewed, and the ashlar work made good; a fine Perpendicular doorway, which had been walled up, was opened out externally, and restored, and this will eventually be used as an entrance, permission having been obtained to remove a monument which now blocks it up. In clearing out this door many interesting fragments were disclosed, which are now preserved in the church.

The roof of the north aisle, being found to be quite decayed, has been renewed in its entire length, and stack pipes have been fixed, where necessary, along the whole north side of the church. The roof of the north transept, which was in a dangerous state, has been strengthened with new principals, to which the old beams have been screwed up and bolted, the old lead has been relaid, and made good; so that the roof is now in a condition of substantial repair.

The works now completed are throughout of great importance to the stability of the building, while the appearance of the whole north elevation, and that of the interior of the north aisle, are very considerably improved. Various other works of the same kind, and scarcely less urgent, are in contemplation with respect to other portions of the abbey, and these it is to be hoped will be commenced upon forthwith.

THE GAS SUPPLY OF LONDON.

It is well known to most of our readers that, after three or four years of agitation, an act was passed in 1860, at the instance of the local authorities, for regulating the supply of gas to the metropolis. That act is now in force, and an exposition of it has just been published, with the title 'Gas Legislation,' written by Mr. Hughes, who was the honorary engineer of the parochial delegates, and took an active part against the gas companies, and to whose exertions the obtaining of the act is in a great measure due. This small volume contains a brief history of the circumstances which rendered legislation on the subject desirable, together with a copious index and a commentary on all the clauses of the act, in which its general provisions are explained, its advantages are pointed out, and in which we are informed how far it falls short, in its protection of the interests of the public, of the bill originally introduced, as drawn up to suit the views of the local authorities. In the historical sketch of the proceedings which led to the passing of the act, Mr. Hughes assumes that his readers are acquainted with many particulars that are not generally known; and as the struggle between the vestries and the metropolitan gas companies—which lasted for nearly four years, at a cost to the parties concerned of at least £20,000—was one of the most important of the kind that has ever occurred, we shall take this occasion to notice it more fully, and perhaps more impartially, than in this volume, written by one of the persons who were busily engaged in the contest.

The metropolitan parishes and the city of London are lighted by thirteen gas companies, the oldest of which, the Chartered, was established in 1810, to light the cities of London and Westminster and the borough of Southwark. As gas lighting became more general it was found that a single company was inadequate to afford the required supply, and the other companies were gradually formed; having obtained permission from the local authorities to open the streets to lay down their mains, by offering to supply gas at a cheaper rate, especially to the public lamps. Thus in some of the streets in London there were as many as four mains of different companies, and the inhabitants had the choice of taking their supply of gas from which company they pleased. This competition had the desired effect, in combination with improvements in the manufacture of gas, of reducing the price rapidly from the original charge of 15*s*. per 1000 cubic feet to 4*s*. 6*d*. in the greater part of the metropolis, and in the City to 4*s*., the latter low price including the use of meters, for which meter-rents are charged in most other parts of London. Much of the competition thus created the gas companies brought on themselves by not yielding to the reasonable requests of the consumers for a reduction in price, and by their overbearing conduct to their customers; for, though in competition, they combined together to keep up the price. The establishment of the Great Central Gas Consumers Company in the City is an instance in point. The City was lighted until 1852 by the Chartered and by the City of London Companies, who charged 6s. per 1000 feet, and meter-rents. They turned a deaf ear to the deputations that waited upon them requesting a reduction in price, and asserted that gas could not be sold remuneratively in the City for less than 6*s*. The Great Central Company was then started, under the sanction of the Commissioners of Sewers, and undertook to supply gas—including the use of meters—for 4*s*. per 1000 feet; but before that company could come into operation the two companies who had possession of the City reduced their prices, first to 5*s*. and then to 4*s*., with a view to prevent the establishment of the new company. Had they consented to reduce their charge to 5*s*. when applied to, the citizens would have been contented; but their obstinacy brought a new competitor into the field whom their too late repentance could not exclude, and the consequence was for a time nearly ruinous to one of the old companies.

Competition having thus produced important practical advantages to the consumers of gas in the metropolis, they were not inclined to look to its ultimate consequences. It is quite evident, however, that the effect of such competition must eventually be injurious to the consumers of gas as well as to those who supply it. Experience in many towns in the kingdom has proved that after a while the competing companies combine, and then the gas consumers are made to pay by increase of price for the unnecessary expense of separate sets of works and mains, and separate systems of management. A combination of this kind took place among the gas companies of the metropolis in 1857. They entered into arrangements to supply separate districts, each company engaging not to supply gas beyond the district to which it was limited, even though its mains should pass through the streets. This arrangement offered many advantages to the public as well as to the companies. In the first place, the inconvenience of taking up the pavement to repair different sets of mains or to change the connections of the service-pipes was greatly lessened; the leakage of gas from unnecessary mains was avoided; and the expense of management was diminished. Had the districting of the metropolis by the gas companies been made in a spirit of conciliation and concession to the gas consumers, all might have been well; but the latter found themselves suddenly, and without permission asked, transferred from one company to another, like bondsmen, and all the dreaded consequences of monopoly were presented to them without any attempt to soothe their apprehensions. Not only so, but one of the gas companies to which the lighting of a parish had been transferred outraged the feelings of the ratepayers by immediately raising the charge for lighting the public lamps. This sounded the tocsin of alarm, and the vestries of all the metropolitan parishes vociferously denounced the gas monopoly that had been created, and banded together to adopt means to release themselves from the bondage of the gas companies. As on all such occasions when public indignation finds vent in vestries, many fallacies and absurdities were uttered, alleged grievances that had little foundation were brought forward, and the gas companies were abused with a degree of violence amounting to absurdity. Deputations were appointed to wait on members of the government, and the *primâ facie* case presented by the delegates was so strong, that a parliamentary inquiry was granted into the state of the gas supply of the metropolis. A committee of the House of Commons was appointed in 1858, consisting of five members nominated by the gas companies, five by the parochial delegates, and of five nominated by the government. The committee sat for five days, during which three witnesses only were examined, all on behalf of the delegates; when the committee determined not to hear further evidence in consequence of the lateness of the session. In the following year the committee were re-appointed, but they postponed their proceedings on the third day, after having examined only one witness (Mr. Hughes), in order that counsel might be employed in the further examinations, and a few days afterwards the dissolution of parliament put a stop to the inquiry.

The evidence so far as it went failed to establish any case of grievance against the gas companies, and even Mr. Hughes himself admitted that the gas consumers had nothing to complain of, but they were apprehensive that they might have if the monopoly were continued. In the first session of the new parliament the delegates determined to bring in a bill for the regulation of the gas supply of the metropolis, but it was thrown out for non-compliance with the standing orders of the House.

In 1860 the bill of the delegates was again introduced, and was referred to a select committee, of which Mr. Estcourt was the chairman. The effect of the evidence given before the parliamentary committee, and the result of cool reflection on the districting arrangements of the gas companies, had evidently produced a complete change in the views of the delegates, for the preamble of their bill, after reciting the names of the metropolitan companies, proceeded to state: "And the said companies, instead of supplying gas by several mains in the same district, have agreed, as far as possible, each one to confine its supply to a separate district, in order to economise capital, and avoid the too frequent opening of the public streets; and, subject to the provisions and restrictions of this act, *it is expedient that such districting* *should receive the sanction of parliament.*" Thus the principle of monopoly, against which the agitation had first been raised, was conceded, and the fight in committee was confined to the restrictions under which it was proposed to place it. During the proceedings the opinions of the committee vacillated first one way and then another, so that at one time the promoters of the bill threatened to withdraw it, because it would be too favourable to the gas companies; and afterwards propositions were made so adverse to the companies, that their counsel withdrew from the committee-room, to reserve their opposition for the House of Lords. The clauses of the bill being then modelled under the sole influence of its promoters in such a manner as threatened almost to confiscate the property of the gas companies, the whole joint-stock interest of the kingdom took alarm when it was reported to the house; and in consequence of the demonstrations made against it, the bill was recommitted. The clauses objected to by the gas companies were struck out, and the others were so altered in their favour, that the promoters of the bill more than once threatened to withdraw it; and probably they would have done so but for the introduction of a clause, to which the gas companies offered no objection, to the effect that the expenses of obtaining the act should be paid by the Metropolitan Board of Works. But for the insertion of that clause all the expenses would have been thrown on the promoters of the bill; and as the ardour of many of the vestries and local boards had greatly cooled during the progress of the inquiry, those who had made themselves responsible for the costs would have been placed in an awkward predicament. The bill encountered no other serious opposition, and it received the royal assent on the 28th of August.

Of the act as it now stands Mr. Hughes observes: "Notwithstanding all the phases through which the bill has passed, and the rocks and shoals on which it so narrowly escaped shipwreck, the act is still a valuable one, and, if not perfect, contains at all events the germ of better and more successful legislation. After much consideration and discussion at numerous meetings of the delegates, it was resolved, on many grounds, to accept it as a whole, and it now remains to make the most of it." The provisions of the act are based on the monopoly which the districting arrangement created, and they are intended to regulate that monopoly in a manner to render it beneficial to the public. In the first place it incorporates the Gaswork Clauses Act of 1847, the most important provision of which is the limitation of the dividends of gas companies to 10 per cent., and, if the profits exceed that amount, the price of gas is to be reduced. The South Metropolitan Company are now in that prosperous condition, and since the passing of the act they have reduced the price of gas 4*d.* per 1000 feet. The Phœnix Company also, which supplies the adjoining district, have reduced their price 3*d.* per 1000 feet in anticipation of quickly arriving at the 10 per cent. dividends, in consequence of the improved position given them by districting. The act fixes the maximum price to be charged for common gas, of an illuminating power not less than twelve sperm candles, at 5*s.* 6*d.*, and for cannel gas, with an illuminating power of twenty candles, 7*s.* 6*d.* per 1000 feet; but no advance is to be made on the prices charged on the 1st January, 1860, unless circumstances arise that will warrant it; the local authorities having power to dissent from such advance, and to refer the matter to arbitration. Each gas company is compelled to provide a place within 1000 yards from their works, with proper mechanical apparatus, to test the illuminating power of the gas, and the local authorities are required to appoint competent officers, and to provide scientific apparatus to test the illuminating power and the purity of the gas. It is one of the essential conditions of granting the monopoly that the companies are compelled to supply gas to all who require it wherever their pipes are laid down; but the companies are empowered to demand security for the payment of the gas consumed, if they think proper to require it; and they are also compelled to lay down service-pipes to supply any house within fifty yards of their mains, provided the occupier of the premises contracts for two years to pay gas rates to an amount equal to 20 per cent. on the outlay. It was one of the grievances alleged against the gas companies that they sometimes refused to supply an incoming tenant with gas unless he paid the arrears due by his predecessor, and this is accordingly guarded against by the thirty-ninth section of the act, except in cases of collusion between the outgoing and incoming tenant; and the companies assert that it was only in cases where they suspected such collusion that they ever refused to supply gas.

The clause of the act which assigns separate districts to the gas companies, also provides for a triennial revision by the Secretary of State, who may alter the boundaries if he think proper, after a complaint made either by the Metropolitan Board of Works, by any vestry or district board, or by twenty inhabitant householders. The districts, there is little doubt, will undergo alteration on the first opportunity, because in some instances the works of the company are situated at a great distance from the district they light.

The provisions of the act respecting public lighting have given rise to much dissatisfaction. The gas companies are compelled to light all public lamps, when not at a greater distance apart than 75 yards, and they are prohibited from charging a higher rate for gas supplied to those lamps than is charged to private consumers. The practical effect of this clause has been a considerable advance in several parishes on the previous rates, as the gas companies, exasperated by a great increase in the assessments on their mains and pipes, have charged the public lamps to the full extent allowed by the act on the estimated quantity consumed. Much difference of opinion is entertained respecting the quantity of gas actually supplied to each lamp, and Mr. Hughes's recommendation, that the gas should be supplied to the public lamps through meters, seems to be the only satisfactory mode of determining the quantity. The application of regulators, which has lately been extensively adopted, has indeed greatly diminished the irregularity of the supply formerly complained of; for the pressure put on the gas in the mains in the early part of the night being always much greater than after the shops are closed, the quantity of gas consumed by the street-lamps varied very much at different times of the night. The small regulator fixed a few inches below the burner opens and closes the orifice through which the gas passes inversely as the degree of pressure, and in this manner uniformity of flame is well preserved.

The illuminating power and the purity of the gas are two important considerations in gas lighting, and the Metropolis Gas Act provides that the illuminating power of common gas, now generally charged 4*s.* 6*d* per 1000 cubic feet, shall be such that a burner consuming five feet an hour shall give a light equal to twelve sperm candles of six in the pound. That degree of illuminating power is nearly as high as can be obtained from common coal, yielding about 9000 cubic feet of gas per ton. The standard of illuminating power of cannel gas, which is supplied by some of the London companies, who charge for it 6*s.* per 1000 feet, is fixed at not less than twenty candles. Mr. Hughes, who is anxious to make it appear that the London public have greatly benefitted by his assiduous and unpaid labours in obtaining the act, states that the standard for common gas is two candles higher than that of the gas before supplied, and he estimates that the gas consumers have thus gained £200,000 a year by the additional light they obtain for the same money. On this point, however, the gas companies do not agree with him, and in the City, at least, where the quality of the gas has for some years past been regularly tested, the illuminating power has averaged more than twelve candles. The mode prescribed for testing the purity of the gas, Mr. Hughes declares, is so severe that very little of the gas manufactured in London would stand the test for ammonia; and he suggests that the local authorities should yield something in this respect if the gas companies will consent to the gas being tested at the place where it is consumed; for the act provides that the place of testing shall not be at a greater distance from the gas works than 1000 yards.

The Metropolis Gas Act has failed to satisfy the expectations of many of those who took part in the agitation for cheap gas, for they find themselves, as regards price, in the same position they were before. What the act does, and what it professes to do, is, to regulate the monopoly of the gas companies, created by the districting arrangements, and without which regulation they might have used the absolute power thus attained to the prejudice of the public. The benefits to be derived from the act are rather preventive and prospective than immediate. It no doubt confers great advantages on the metropolitan gas companies, by sanctioning their monopoly of supply, but if its provisions be fairly carried out, it will secure to the public a participation in those advantages; and it unites the interests of the suppliers and the consumers of gas, by making the reduction of price dependent on the prosperity of the gas companies.

THE DARK AGES OF ARCHITECTURE.*

By J. P. Seddon.

I am somewhat afraid lest by the title selected for this paper I may have lured hither under false pretences some mistaken lovers of Mediæval architecture, in the hope of hearing a treatise upon their favourite phase of art;—not, I trust, that any could suppose I am capable of endorsing the stigma upon it which such term was intended to convey, but it is possible that some may have thought that I proposed to enter the lists in its behalf in the character of an apologist. Should any have been so misled, they must pay for their mistake by their disappointment, if such they deem it; for I hold that calumny to have been long ago refuted. The Dark Ages to which I am about to refer are quite other than Mediæval, as far at any rate as architecture and the other arts are concerned. They are those, the central or midnight century of which—if we may credit the historian Carlyle—lacked light in other senses besides the artistic, being as regards political or moral honesty also "bankrupt,"—certainly in all matters of taste they were steeped in the deepest gloom. The picture I cannot promise to make inviting, but it may nevertheless be in some degree instructive, and show us what to avoid,—a lesson not less valuable than that which teaches us what to study and adopt.

As the Dark Ages of architecture do not then date from the birth of the art, they do not include, nor do they necessitate, any inquiry into the probable form of the wigwam of the pre-Adamite man, if any such existed; nor need I trouble you with any speculations as to the early efforts of the *pre* or *post* Noahites, which perhaps some millions of years later may have preceded or followed the fabled transition of the type of the timber hut into that of the stone temple;—for such essays in building cannot claim a title to the name of architecture at all, or if any be inclined to concede it to them, it could be but as architecture in infancy, and therefore, even if only babbling by the light of nature, not altogether dark nor dead: its glimmerings, if but the first of the dawn, are surely, though slowly, about to broaden into daylight; the men who wrought it were looking forward, not backward; they were gaining step by step in advance, never pausing; one nation taking it up where its predecessor left it, each meanwhile giving it some individual impress—adding some new thoughts to the general stock, and fusing them into a consistent and intelligent whole.

Thus we may trace art from age to age, until the Dark Ages, and find that it was ever a language wherein men simply and naturally expressed what there was in them to tell, and which we may read with an assurance greater than even that we can give to their written records, seeing that there is less likelihood of their having been tampered with.

As from the bowels of the earth our geologists are digging new fossil facts, which explain or correct our misreadings of sacred writ, so our Layards and Newtons are excavating from more recent strata actual fragments of buried Assyrian cities and mausolei, in Asia Minor, which in like manner throw new light upon profane history, and convict half our cherished traditions of being mere fables, putting us as it were face to face with the kings, priests, and warriors of those ancient days, which had become to us almost as obscure as the "mornings and evenings" of the creation, with their wondrous intervals. So it is with the kings of Egypt: their acts, and all they did are chronicled on the walls of granite and sarcophagi of basalt lately visited and ably described by Prof. Donaldson; and, in these days of railways, we can quickly re-unite—in the mind at least—the sculptures of the Parthenon housed in our Museum, to their empty sockets in the ruins of the temple or the Acropolis of Athens, and so gain a glimpse of that perfectly beautiful art, in which the polished Greek sought to represent his ideal of the divine.

Then the Roman has left us his notions of architectural showiness, in his versions of the five orders; which, whatever they may be worth, were his own, until eclecticism in the Dark Ages confounded all nationality and propriety in such matters.

Even the Byzantine, in whose hands art seemed to stagnate for a season, wrought out in his unmistakeable manner the types tradition handed down to him, and set the dome as his sign-manual over the crux and each arm of the churches which he built on that plan of his—"the Greek cross."

The Arab, again, had his slim minarets and fretted domes, with an array of pointed and stilted arches, whose curves seemed to have been fashioned after that of his own falchion.

The barbarians also, who overturned the Roman empire, and settled down upon its lees, gave sense and nerve to the effete nonsense which they found in the shape of decorative art in that Classic land, and thought out for themselves a better (being the proper) way of using the archivolt, and wreathed the tame foliage of the Corinthian capital into something like the grace and freedom of nature; and told in their sculptures, without reserve, what they themselves believed in, loved, and were amused by.

Then followed, surpassing all previous efforts, the Gothic or Mediæval development of art, the grandest, noblest, and most scientific which the world has seen; for even if, in its restlesss strivings after conceptions of beauty, seemingly as infinite in their variety as in the number of its works and its schemes for realising them, it sometimes overshot its powers; and making not sufficiently sure of its substructure, in haste to soar upwards, prepared for itself such catastrophes as those recorded of the towers of Winchester and Ely by Prof. Willis, and that just witnessed at Chichester; we have yet hundreds of other examples, equally fine, which have lasted for centuries, and may last as many more. We may therefore still be more thankful for its lofty and noble aims, despite such occasional failures, than for the lower, if safer, aims of styles content to grovel near the ground, and whose superior science consists in poising huge stones upon columns, in ignorance of the principle of the arch, whereby the space could be better spanned, and in avoiding every chance of thrust, in order to escape a difficulty which they knew not how to deal with.

Throughout all these several styles not one link in the chain was lost, not one lying phase had yet appeared. We may approve one more than another—we may find errors and backslidings; but no systematic and deliberate falsehood and betrayal of the spirit of the age can be found in the whole history of art until we come to the Dark Ages. The Greeks seem to have been gifted rather with consummate refinement than with much originality. We can well see that they admired and borrowed from the ornament of Persia and Egypt, but we have no proof of their having attempted to build Egyptian Halls in the streets of Athens, or sham Caves of Elora about its Acropolis. The Christians, when freed by Constantine from the persecution which had repressed all their previous efforts, boldly adopted the pagan basilica for their churches, and built others after the same type; yet we do not find that they attempted to compose them out of porticoes copied from the antique, or piled Grecian monuments one above another to serve for belfries or campanili.

It is a question of the greatest moment to us, but one which I have not time now to discuss, how it was that the Mediæval or Gothic phase of art should, after its brilliant and rapid growth, have rested so short a time at the height of development which it reached, and thence declined with almost equal rapidity, till it fizzed itself away in France in the luxury of "Flamboyant" tracery, and in England was strangled in its straight-jacket array of the rigid "Perpendicular." It suffices for our present purpose to know that it died from inherent decay, and not from any assault from without. That this, as every other style that preceded it, should have gone the way of all things of earth, may be a matter for regret, yet not of surprise—and its having done so is not the question which I have proposed to consider on the present occasion; but rather, how it happened that after it came "the deluge." We have seen that all previous styles successively rose, culminated, and fell, only to be followed by others still more comprehensive; and that each yielded up gracefully all that it had added to the general stock of ideas, to be grafted into the newer plant, to bud and flourish again with fresh vigour and increase of power under a different *régime*.

What then necessitated the artistic chaos which reigned when Mediæval art vanished? What was the Gorgon's head which turned into stone the natural love for and power to originate beauty which mankind had hitherto shown in all ages and countries? These are the questions to which I am anxious to find a solution. The complete quenching of the lamp of art, which sooner or later, in the period of the Dark Ages, ensued in every quarter of the globe (save where, among the less civilised Oriental nations, it has stagnated until now in considerable decorative purity), is one of the strangest phenomena I am acquainted with in the history of the world; and this I desire to invite you to consider, in the hope that we may be able to discover the rocks upon which it was shipwrecked, and that in our efforts to float it again we may be able to steer clear of them.

The Dark Ages however, or at least the gloom of them, did not come all at once. The night, unlike that of the tropics, did not follow suddenly the light of the Mediæval day. Nay, the sun of art set so gorgeously that men were dazzled by the glory thereof, and believed that it was a sunrise heralding a new, better phase of art, instead of its being a sunset preluding the loss of the best the world had seen. It behoves me therefore to linger over this threshold of my subject (and not unwilling am I to do so, seeing that it is by far the pleasantest part thereof), and to endeavour to trace the lines of its several changes as successively they grew fainter and fainter, together with the brightness of the evening stars of genius which beamed like a galaxy through its twilight, and even occasionally long after the nightfall; until, clouded over at last, utter darkness ensued, enlivened only by the false Will-o'-the-wisp phantoms of *rococo* which have been misleading men ever since.

---

*Paper read at the Royal Institute of British Architects.

This period then, upon which I should now dwell, this twilight of the Dark Ages which I have taken for my subject, is that generally known as the Renaissance, or the revival of Classic art. It is true that in Italy, the whole surface of which was strewn with fragments of Roman work, Classic tradition seems always to have sat like a nightmare upon its architecture: the mighty flood of life which seems to have throbbed through the arteries of Northern Europe appears to have been checked in its passage through the gorges of the Alps, and to have exercised but slight effect below them, and never entirely to have succeeded in supplanting the influence of the antique. It succeeded in doing so to the greatest extent in the thirteenth century, and with much grace for a time fused the two styles; but soon it began to hanker again after its old love, and we begin to find the mouldings of its Gothic buildings becoming poor and weak, and its parts and proportions betraying more of the Classic elements. In Venice, which from its position was not so strongly exposed to this influence, and which was greatly under that of both the Gothic and the Byzantine, we find in the Doge's Palace a most valuable and nervous example of Mediæval building, unsurpassed in the boldness of its mouldings and detail; yet, if we consider the general aspect of the domestic architecture of that city, we shall find little of the variety which was so marked a characteristic of Northern Gothic, it being similar in detail to that of the Doge's Palace that we find repeated everywhere; while that of the churches of the Frari, and those of the same date, are strikingly inferior. In Verona we find another most valuable local development of Gothic, particularly artistic in its treatment of coloured material and sculpture: still, an under-current of Classicism is evident throughout Italian work. In the Cathedral of Milan it has debased it so far as to render it only worthy of being a model for confectionary.

In Florence and in Pisa we are so entranced by the wealth displayed in their buildings, of painting and sculpture and precious coloured materials, that we are consoled for the want of pure Mediæval feeling and boldness in the handling of the architectural detail in such works as pretend to be Gothic; and in the host of false façades to the churches in the other towns, such as we see figured in the plates of the works of Hope, Gally Knight, and Street, we see foreshadowed the childish shamelessness of sham which mainly characterises the later works of the Renaissance and those of the Dark Ages, which ignores the certainty of being found out the instant the spectator turns the corner of the building. In the Loggia di Lanzi, by Orcagna, we find distinct traces of the Roman impost between the columns and the arches; while his Or San Michele, in the tabernacle and the tracery of the windows, presents us with work we might almost mistake for that of Batty Langley. In the pulpit by Andrew Pisano, in the Cathedral of Pisa, we see in the figures and draperies of the bas-reliefs evidences of an already too-absorbing study of the antique, in contrast with the vigour shown in the beasts upon which the alternate columns rest, where the sculptor has evidently treated them *con amore*, and rather with the traditional Mediæval feeling; while the capitals of the columns are almost as bad as the Roman composite; and the weedy apologies for cusped trefoil arches are the only traces of Gothic forms.

About the middle of the fourteenth century there arose a *furore* for the study of Classic literature (which, indeed, had been more studied during the Middle Ages than we generally credit, but then in a healthy way, as food to be digested, and not so insanely bolted, after the manner of bookworms, as afterwards): antique manuscripts became eagerly searched for and pored over by the *literati:* fragments of sarcophagi, and every production of Rome's New-road masons' shops were studied by sculptors, and voted to be admirable precedents: the ruins of the Coliseum, of the temples of the Forum, and of the triumphal arches, were diligently examined, and their proportions measured, and admired out of all proportion with their merits; and, as ill-luck would have it, a somewhat dogmatical treatise upon architecture, by an old gentleman who lived during the unpropitious days when Augustus had just strangled the Roman Republic, and who was doubtless a highly respectable member of a very worthy professional body at that time, was just then brought into fashion; and a number of suggestions that he had made for the guidance of his pupils and professional brethren, whom he had the sense to see (for he was a very sensible man) were not to be trusted to think for themselves, were propounded as a code of laws to regulate architectural practice and to serve as canons of taste. The works of Vitruvius have since passed through many perhaps too highly valued editions; while a contemporary architectural romance—'The Dream of Polypholus,' which is replete with artistic suggestions, has passed through too few. Most fortunately, the painters were not so successful as the sculptors and architects in their researches after the antique; and thoroughly can we sympathise with Rio, who, in his 'Poetry of Christian Art,' rejoices that no picture by one of the celebrated masters of antiquity was brought to light; for, says he, "Had this been the case, modern art would have been in possession of a model from which an unalterable rule of taste and an unerring theory of the beautiful might have been deduced and applied to painting." It was owing to this want of success on the part of painters, and to their being forced to trust somewhat to their own resources, that their art flourished longer than its sister arts, and that in dying it shone, as the dolphin is said to do, with brighter hues than during its life, casting not inconsiderable radiance over the decay of the rest.

It was, then, the unfortunate discovery, galvanizing, and deification, of the exhumed bones of the *Classic*, or to speak strictly, ***Roman*** art, which was the veritable Gorgon's head that paralysed true and healthy art. Its influence was doubtly fatal: first, by substituting precedent for thought; and, secondly, by substituting second-hand paganism for Christianity. One result of the undue regard for precedent was, that *the people* (for whom artists ought to paint, sculptors to carve, and architects to build, rather than for their own compeers)—caring comparatively little for the defaced bas-reliefs and broken columns, whose stories had become obsolete, and whose purpose was unintelligible to them; and the subtle mysteries of proportion being beyond their comprehension, or at any rate but a small compensation for the loss of the human interest and phonetic power of the class of buildings to which from Mediæval times they had been accustomed—began to lose all interest in the works which they saw rising around them. They found that these very learned architects shot completely over their heads; and that, when they asked for artistic bread, they got naught but stones. Certainly we do not hear of bed-ridden old men asking to be brought daily to look upon any of the master-pieces of the Renaissance, as had been the case with the campanile of Giotto at Florence; for, in truth, theirs are not "bright, smooth, sunny surfaces of glowing jasper"—they have no "spiral shafts and fairy traceries" for the eye to delight in; but rather uncouth, rugged, prisonlike rusticated walls and frowning cornices, such as those of the palaces of the Strozzi and Ricardi at Florence, and of the Farnese at Rome, which plainly told them "we were built to keep you out." And even if any from the love of novelty should in those days, as some, I am aware, from the force of prejudice have in these days, turned from the Doge's Palace and St. Mark's at Venice, to the contemplation of the Library, by Sansovino, on the opposite side of the Piazzetta, one would think that when the natural surprise at seeing so many almost identical females, angelic by virtue of wings alone, somewhat awkwardly cramped into every pair of spandrels throughout the building, had subsided; and when sufficient pity had been bestowed upon the Cupids in the frieze, each condemned to bear in symmetrical balance on either side of him a swag of flowers altogether too heavy for his size; that the proportions of the building, admirable though they may be, would not detain a spectator long after he had exhausted the iconography which is so happily suggestive of its literary destination. The consequence of all this was, that the public ceased to ask for pleasure or instruction at the hands of architects; and the latter forgot that it was their duty to tender it, and, as if in revenge, hedged themselves about with a set of rules (the observance of which could, of course, only be appreciated by the initiated), in oblivion that art should "pierce directly to the simple and the true."

But the substitution of second-hand paganism for Christianity was even more fatal than the slavish adherence to precedent. It is absolutely impossible to produce good work without faith in what one is attempting to realise. In such faith had lain the strength of the early painters, in whom we can excuse shortcoming in their powers of execution for the sake of the purity and earnestness of their aim; for, while men wrought in the spirit of the statement of Buffalmacco, recorded by Vasari—viz. "we painters occupy ourselves entirely in tracing saints upon the walls and on the altars, in order that by these means men may, to the great despite of the demons, be drawn to virtue and piety;"—and so long as the intention of works of art remained the same as that named in an inscription over the doorway of St. Nixier, at Troyes, viz., that three windows had been painted "pour servir de catéchisme et instruction du peuple,"—we may foretel their success, and that step by step they will overcome the difficulties and technicalities of their profession without the aid of infallible precedents from the antique. But when they began to pander their art, at the bidding of princely patrons, to the representation of the labours and loves of Hercules and Venus, and other of the gods and goddesses of pagan mythology, we may as easily prophecy that, notwithstanding such splendid genius and wondrous powers as those of the artists who congregated around the corrupt courts of Leo X. and the Medicis, the system has become rotten to the core—the lamp is but flickering with an unhealthy excitement which but preludes the extinguishing of the light altogether. Such was the fact which ensued. The very prowess of Raffaelle and Michael Angelo seemed to prevent their successors from making use of the powers they undoubtedly possessed. They prated of the composition, the drawing, the colouring, the chiaroscuro, of their great masters, and humbly strove to follow them with such success as they were able to command in these particulars; but they seemed, in their struggle after the means of art, to forget the true object and end of it: and one may commend their diligence so long as they confined themselves to the representation of subjects from profane history or mythology; seeing that it is of comparatively slight importance whether Alexander or Darius be caricatured or not in a picture which pretends to no accuracy, even in costume; or whether Juno or Venus appear questionable in point of character, if not of beauty, seeing that no one is called upon to believe in either their existence or their virtue; but one cannot but regret the misapplication of their efforts to represent the persons or scenes of sacred history. Thus, Caracci was far better employed upon his famed Butcher's Shop, than upon his Three Marys, weeping their crocodile tears; and Guido upon his Aurora amidst the clouds, for the future admiration of the dozen or so of devoted students who may always be found copying the same, to the not very evident advantage of modern art, than upon his sentimental Madonnas and Ecce Homos.

I have dwelt longer upon the effects of the Renaissance upon the painters than upon their brother artists; because, as I have said, from their fortunate failure in finding Classic models, and the consummate excellence of some of their craft, the meteoric brilliancy of their fall was the more striking, and the warning it conveys necessarily the more patent; nevertheless, the same fate befel all the other arts, including that with which we are more nearly concerned, and to which my wasting space warns me I must now confine myself.

Let any one who would question what I have advanced, or who desires to study Italian architecture, and the end to which it led, in a simple spirit of common sense, take up Quincy's 'Histoire des Architectes,' and turn over the plates in their sequence: the first, representing the cathedral at Pisa, the work of Buschetto, in 1063, and the few next in order, he would find clearly demonstrating what I have stated as to the trammels by which, during even the Mediæval period, the attempt to introduce into Italy the architecture which was then flourishing beyond the Alps was restrained by the natural predilections for the antique. The plan of this cathedral—that of the Latin cross—its apsidal ends (reminiscences of the fatherland of its architect), its clerestory and ranges of arcades, and the Byzantine feature of the dome over the crux, are insufficient to conceal the preference for the horizontality of the Classic school, or to excuse the *mesalliance* of the Roman order with the arch. This latter is seen still more uncouthly in the baptistery by Dioti Salvi, in 1152, where gables and crockets parodied from the Gothic are added. However, the fusion of the two elements, with greater skill, and so much beauty of proportion and treatment of precious coloured material as to demand admiration as a style *per se*, are represented by the works of Arnolfo di Lapo and Brunelleschi in the cathedral, and of Giotto in the campanile, at Florence.

In the palaces of the Medici by Michelozzo, and of the Strozzi by Cronaca, at Florence, we seem to lose sight of the desire to please which the other buildings I have named show by their unsparing luxury of marbles and mosaic and thoughtful delicacy of detail throughout; and are made acquainted with the stern grandeur and air of shrug-the-shoulder affected by the turbulent and selfish Italian nobles of the fifteenth century in their fortress palaces, which however still depend for no small nor inferior portion of their effect upon the almost Gothic treatment of the windows, together with the (to my mind) exaggerated frown of their heavy cornices of Classic type.

Then painfully evident is the study of the antique in the correct proportions, but tiresome monotony, of the arcaded side of the church of St. Francesco at Rimini, by Alberti: each arch with its precisely similar sarcophagus, and each pier with its rectangular tablet like a picture-frame, each spandrel with its circular panel like an *immortelle*;—strangely commemorative, but hardly symbolical, of the career of the restless Sigismond Malatesta and his generals, who were probably not all cast in the same mould. How differently such a theme would have been treated in Gothic hands, let the monument of Aymer de Valence and its neighbours in the choir of Westminster suggest, or the tombs ranged along the aisles of the church of the Frari at Venice.

In the Palazzo Pandolfini at Florence we must needs bow to the consummate feeling for proportion wherein the genius of Raffaelle is portrayed; though I think we cannot but regret that he did not, as he might so well have done, give reins to his imagination, and treat us to something a little more phonetic than alternate segmental and triangular empty pediments. Yet if we dare not do other than confess their perfection, we may plead that sufficient changes have since been rung upon this slender theme, with alas! too seldom the same plea of admirable *proportion* for an apology which this building and that of the Palazzo Farnese at Rome can undoubtedly put forward.

The distinctions and merits of this Florentine and the Roman and Venetian types of the Renaissance have been so well explained by Mr. Garbett in his 'Rudimentary Treatise on the Principles of Design in Architecture,' as to render it unnecessary for me to do more than refer an inquirer to his remarks on the subject; and simply to note, in following our present author, that we find as examples of the second class the works of Giulio Romano at Mantua, and of Michael Angelo at St. Peter's,—honourable of course, to a greater or less degree, for proportion, but generally contradictory of truth, in ignoring the necessity of floors in buildings by the use of single gigantic orders of pilasters for their exteriors, and for the method of veneering the same to their façades. Triglyphs, from the examples I find in the plates under examination, seem to be the main if not the single idea of decoration; and for the pertinacity with which so happy a feature is kept before the mind we ought, no doubt—though I own my inability—to be truly grateful.

Of the Venetian type, by which I understand the decoration of each floor by an exterior order, we have the Library of St. Mark, by Sansovino, at Venice, of which I have already spoken; the Villa of Caprarola, and the Palazzo della Ragione, at Vicenza. But though we have not the noble Palazzo Grimani at Venice, by San Michele, nor any of the picturesque painter-like conceptions of Longhena, such as the Palais Pesaro at Venice—which if not so pure in detail commend themselves to me for artistic grouping and conception before most of the ordinarily idolised Italian buildings—these Venetian works, with their pomp and luxury of effect, their successive orders of columns, constant use of coupled columns, depth of recess, and richness of detail, seem to typify the vanity and love of parade of the age which gave them birth, and which preluded the downfall of the city they adorned. I do not remember ever to have been struck more forcibly with the character that architecture can present than by the puerile vanity shown in many of these façades in Venice; for while the old Moorish and Gothic palaces, marred as they almost all are by later incongruous additions and insertions, though comparatively modest and unaffected, have sensible fronts, more richly arcaded and decorated of course than the sides, yet in harmony therewith, so that they are one conception and construction—these fronts of the Renaissance buildings are all separate show façades, stuck as it were before a building of totally inferior and distinct character, just returned round the angle a few feet to save appearances, which of course is found out as soon as one has turned the corner.

Such are the three grand types of the Renaissance architecture of Italy, as developed principally in Florence, Rome, and Venice, and whence sprung the architecture of the Dark Ages to which the plates of the second volume of Quincy introduce us, but all the series of which I have neither time nor patience to follow.

From Italy the Renaissance spread into France, a result doubtless hastened by means of the Italian wars of Charles VIII., Louis XII., and Francis I.; but at first the native workmen merely applied the more ornamental parts to their own Gothic work, as in the Chateau de Blois. Subsequently they developed it into a style of their own, of which Chambord and Chenonceaux are among the most favourable specimens. It may be described as consisting of the application of pilasters, more or less enriched, as surface decoration, and these are in fact made to do the duty of the buttresses which were so profusely employed in Flamboyant. There is much beauty in this style, which was the work of French architects, and became naturalised in their land. It is very artistic, and less insolent in its display of barren proportion—it gives something more than that husk of art. At the same time, it is, like all Renaissance work, radically wrong and inconsistent as architecture compared with the real styles. Its very notion of ornament is something added to and independent of the construction. It is highly picturesque, but generally exaggerated in its grouping and skyline, and combinations of turrets and high roofs,—its best features, which it borrowed from the Gothic.

In the latter years of Francis I., Italian workmen and architects were imported into France, and were employed at Fontainebleau. They introduced a great modification into the style, partaking more of the Classic feeling; after which, as was natural, it rapidly deteriorated, and passed through the phases of the style of Louis XIV., set forth in the pages of Le Pautre, redolent of gilding and parade: thence it sank, in the times of Louis XV., into that vicious and emasculated style which has earned the soubriquet of "rococo," in which all the grandeur—manly, if somewhat heavy and impure—of its predecessor gave place to an elaborate trifling with florescent knucklebones, in curious combination with a species of shellwork,—altogether an idiotic piece of business, which we might dismiss without a thought, save of scorn, were it not that this in the depth of the Dark Ages was the very Will-o'-the-wisp which architects and decorators danced after, and upon which, even so late as in the Great Exhibition of 1851, most of the productions of *civilized* nations were based; so that one had to turn to the works of the *barbarians* of the East, as to an oasis of true art, to refresh one's eyes with. Whether or not in the interval our efforts to imitate these, on the one hand; and to teach the Chinese Palladian plasferwork, to smash palaces in Pekin, and to loot at Delhi, on the other, may have turned the tables, we shall shortly learn.

The course run by the Renaissance in England we may take up at the period of Elizabeth; when, the political troubles becoming settled, men were able to turn attention to art and architecture. For a long time the traditional construction and plan and the mullioned windows held their ground; but coarse bad Pagan mouldings were introduced as improvements, and an equally coarse sort of adaptation of French ornament was developed into a convenient store of precedents for the Dark Ages. Stone was made to assume the appearance of cardboard, cut and curled; and monstrosities of every description were delighted in.

This Elizabethan style was that which in England combined the features of the decaying Gothic with those of the revived Classic; and, though less refined in detail than the contemporary work in Italy and France, was perhaps the most vigorous and picturesque. In time however, here, as on the Continent, the Classic element conquered in the struggle: purity of style and correctness of proportion, in imitation of Roman precedents, were the objects architects set themselves to attain;—and so were ushered in "the Dark Ages." Yet many revered names there are among these architects, from whose reputation I desire in no degree to detract: I only lament that their lot fell not in better times. What I seek to show is, not that Inigo Jones, Wren, Hawksmoor, and Vanbrugh were not great men, but that they were all the greater for having wrought out so much that is grand and graceful from elements lacking these qualities themselves, and which, when their genius was withdrawn, resolved themselves into the monotony and lifelessness inherent in them. Of the heroes who led this forlorn hope, Inigo Jones was the first and best. The proportions of his design for the portion of the Palace at Whitehall which was carried out are as generally admired as they are known; but as it has been used as a precedent for myriads of acrobatic pilings of orders above orders, and breaking the entablatures over to give them some appearance of utility, we need the less regret its not having been repeated by himself. It is strange that one who so thoroughly appreciated the importance of purity and consistency in the style in which he worked himself could have so little regard for the same qualities in other styles, as to have built to the old Gothic cathedral of St. Paul's an incongruous pagan porch, and refaced the transept end in a manner which, fortunately for his reputation, lives only in tradition. This also has been much lauded for its proportions; but, from the representations of it that exist, I confess I cannot regard it with enthusiasm. That it was however simply barbarous, as an adjunct to a Mediæval cathedral, we may I think assume, from a comparison with the effect of the alterations made by another architect, who was not otherwise than a shining light among the constellations of the Dark Ages, to another of our cathedrals. I mean those made by Wood, of Bath, at Llandaff. Now, the works of this architect at Bath are by no means bad of their kind, and would not lead us to suppose that he could have been guilty of the atrocities which I fear can with too great truth be laid to his charge; any more than we should believe, upon less certain documentary evidence, that Inigo Jones had maltreated in a similar manner the façade of St. Paul's. Of the alterations to Llandaff I have enlarged the illustrations given by the Bishop of Llandaff in his work upon that cathedral, showing the design "as it was proposed to finish it;" and we learn, from contemporary letters quoted by the Bishop, that it was proposed to pull down the two western towers, and raise one over the front of the nave, as seen in the design, and "then to finish with a rustic porch." Most fortunately the solicited contributions of the faithful were not sufficient to enable them to realise this conception. We learn, however, that they succeeded so far as to insert "windows framed with wood of another sort, which will come vastly cheaper and look as well as the Gothic," and to finish the interior in "stucco" to their own satisfaction; for the same letter states, "that the church inside, as far as it is ceiled and plastered, looks exceedingly fine, and is a very stately and beautiful room."

Sir Christopher Wren had by no means the same artistic feeling as Inigo Jones, though greater mathematical powers and science in construction. As an architect he had golden opportunities in the rebuilding of the city of London after the fire of 1666, and he had the genius to grapple with it in an engineering point of view, and architecturally also, so far as it was possible in the style with which unfortunately he had to deal. The manner in which he did this has been so lately thoroughly set forth by Mr. Kerr, that I need not here enlarge upon his works; the more so, as my purpose of showing the thorough intractability of the style, which even his talents could not overcome, is rendered self-evident by the following remark, which I venture to quote from that gentleman's lecture on the subject. Speaking in reference to the double dome and screen walls of the nave of St. Paul's, he says—"They are at least the makeshifts of marvellous ingenuity and still greater artistic power: they are falsities, it is true, but they are those of a master-mind—they are no common, vulgar fibs, but grand lies of genius." Now a style that necessitates lying—which requires "marvellous ingenuity and still greater artistic power" to conceal awkward roofs and buttresses, at the cost of making one-half of a building a huge sham to render the other half tolerable—is, I think, fairly to be said to belong to the Dark Ages; and that Mr. Kerr's estimate of the makeshift is a correct one, my reminiscences of a church in Venice by Palladio, the roof and buttresses of which had not been concealed by such ingenious means, yet which seemed to call loudly for a similar friendly shelter, will enable me to corroborate.

The group of the City spires and the towers of Westminster Abbey, are conceived and massed with great talent and a true feeling for what is grand and picturesque; yet such horrible details, such a substitution of the queerest pots and jars in the place of pinnacles; that it is necessary that one should half-shut one's eyes to enable one rightly to appreciate their outlines; and as such are, after all, borrowed from the older Mediæval steeples, one would really rather open one's eyes, and see true Gothic steeples, with proper detail as well. The thin leaden spire of St. Martin's, Ludgate-hill, is, as a composition, righly placed in contrast to act as a foil to the dome of St. Paul's; but in itself is surely no beautiful object.

Time fails me to describe other of Wren's works, or those of his successors who took up his mantle—of Hawksmoor, Vanbrugh, or Chambers, and the rest of the band of that forlorn hope, despite whose efforts architecture sank down gradually to the uttermost depth of degradation, when the idea of associated English homes was the monotonous dreary walls of Harley-street, and such like—wherein Sham reigned triumphant from palace to terrace, in plan, construction, and decoration alike. Art and architecture became absolutely dark or dead; and copies or parodies of the works of other days were all that was attempted. The only merit that can be claimed for them is, as usual, that of "proportion,"—an element certainly so essential that there can be no architecture without it, yet one the exclusive praise of which is a sure sign that there is little else to praise; just as the most sarcastic thing you can say of a man is to laud too highly his good-nature; the meaning of which usually is, to suggest doubts as to his sanity. To wade through the works of this dreary period, either for the purpose of description or reprobation, would be a task the uncongeniality of which, together with the undue length to which I find I have extended what were intended to be prefatory remarks, must be my excuse for now shirking what might appear to be the subject I really undertook to treat upon. I cannot but own however that it is with some satisfaction that I find the ordinary limits of a paper reached without the necessity of an inquisitorial journey into the City for examples to criticise. In the first place, I am spared the necessity for becoming spiteful; in the next, a chilling reminiscence of the interior of St. Paul's indisposes me to revisit it until it shall have assumed—as we trust it soon may—all over, and not here and there only, in the able hands of our honorary Secretary for Foreign Correspondence, richer hues, akin to those of St. Mark's at Venice, since we are promised the use of the same materials for its decoration. Then it might have become incumbent upon me, however disagreeable, to sketch and measure the extraordinary sham portico set up by Sir John Soane at one end of the court of the Bank; to match—according to a favourite notion in the Dark Ages—a real one at the other. Again, I had feared that it would be necessary to study the interior of Sir John Soane's Museum; which otherwise, not having a fancy to become a candidate for residence in that strange eclectic curiosity-shop, I had been content to seek amusement from in the illustrated catalogue of its contents.

I had also been afraid that it would be necessary for me to search and see how far I could agree or not with Lord Palmerston in his admiration of the several buildings which he was pleased to call Italian; and, as the Horse Guards was one scheduled in his list—the only pleasant features of which, to my mind, are the sentries in their uniform, who sit, like gorgeous personifications of "Patience," inside, instead of "on a monument," —the prospect, I assure you, afforded me slight satisfaction. I find myself also obliged to omit all consideration of the interesting question of the Iconography of the Dark Ages; and all research into the origin of the type of cherubs who smile and weep in convenient alternation upon keystones; or into the meaning of the lions' heads whence dangle flowers to fill up panels; or into the purpose of the sundry pots that affect all high places. The question also of the Polochromy of the Dark Ages I find myself obliged to omit or postpone, unwillingly, because on this subject much instruction might be drawn as regards what should be avoided. The main ambition on this point seems to have been to keep on the safe side; and *safe* colours which could do no harm, and whitewash, reduced the interiors of buildings to a similar condition of monotony to that we have remarked in the exteriors.

However, about the close of the last century, there appeared to be commencing a salutary "shaking among bones" (to quote again the phrase of Mr. Ruskin) in an artistic as well as in a political sense; and though it seemed for some time difficult to discern whether these were real evidences of resuscitation among them, and whether such shaking were likely to bring any flesh upon them, we at this period of time are able to perceive (at least we flatter ourselves so) that, through all the restless changes which have ensued in the successive fashions of copyism since then, there has been, beneath the outer garb of Greek and Elizabethan, of Roman, Florentine, and Venetian, Renaissance or Mediæval revived styles which have met the eye, an undercurrent of healthy struggling to attain independence. Just before the Exhibition of 1851, in another lecture, I asserted my belief in opposition to that of the author above quoted, that not bones alone were being shaken, and that we were upon a sure if slow route to progress. The coming Exhibition of 1862 will, it is to be hoped, by its contents if not by its *carcass*, afford another favourable opportunity for taking stock, and another starting-point in the road of progress.

What colours are the best to fight under in the future struggle for the advancement of architecture in which we shall be all engaged, I must leave to the conscience and calm consideration of each. As to what style may be the best to develop into a healthy, manly, Christian, English, Victorian, architecture, I presume not here to dictate, since we differ in opinion on the subject. It is well that we think not all alike, and are not content, as in the Dark Ages, like sheep to follow blindly a leader in all things. But let us fight out the battle, if battle it is to be, in a legitimate and friendly way; without deputations and special pleading on the one hand; yet without fear as to throwing stones, because both parties live in glass houses, on the other hand. Let each be thankful to the opposing side for pointing out its weak places, and turn manfully to repair them. There are plenty of what my friend Mr. Burges calls unnecessary "fizzings and crockets" and show buttresses, as well as vases and rustications and sham pediments, which may be offered up in a holocaust together; while there is equal room for each party to endeavour by practice to prove what their champions have been so vehemently asserting—viz. the capacity of their favourite style to admit the highest art in painting and sculpture; and thus, whichever side conquers in the friendly struggle, both may rejoice alike, and the monotony and follies of the "Vernacular" style, as Mr. Scott calls it, which has descended to us as a legacy from the Dark Ages, be left to the speculating builders who delight therein.

In the Discussion—

MR. PAPWORTH observed that Mr. Seddon was not alone in depreciating Vitruvius. He however was inclined to ask, how many copies of Vitruvius were in MS., or known to exist? and who made them? The majority of copies were not of the thirteenth or fourteenth century, but of the twelfth, eleventh, tenth, and ninth centuries. His belief was, that if a little attention were paid to the subject, it would be found that the Mediæval architects of the eleventh and twelfth centuries thought that they were following Vitruvius as closely as they could. He wished to know who it was had taught the architects of the Middle Ages. Among the records and muniments of Italian cathedrals constant reference would be found appealing to some unknown authority, and he believed that that authority was Vitruvius.

MR. BURGES said he had never met with Vitruvius in Mediæval architecture. All he knew on the subject was, that he had not been able to trace him in eleventh, twelfth, or thirteenth century art. That he was extensively copied, however, there could be no doubt, and so were Ovid and Horace.

MR. GODWIN said he did not desire to discuss the wide question opened, but he thought it right it should be understood that all present, though silent, did not concur in what, as it seemed to him, must be considered a general sneer at the great minds who in the sixteenth century—the period of the Reformation—the period of Bacon—had aided the world in the awakening of thought. He could not call that a Dark Age.

MR. SEDDON said he thought he had a perfect right to express his rooted convictions—convictions which he had always endeavoured to propound, because he believed all the hope they had of good architecture for the future lay in their comprehension of these points.

MR. KERR said there was, he thought, something more in the revived Italian architecture than Mr. Seddon was prepared to admit. The human mind never worked without materials; and it was absolutely necessary that at the period referred to it must have returned to the remains of Classic times. The human mind, turning to the remains of Classic Rome, found a system as different from that which had perished as could possibly be. It found in the remains of Roman architecture, sculpture, poetry, philosophy, and history, examples upon which it could with great credit to itself rely, under the circumstances in which it was placed. These remains were adaptable to the wants and circumstances of the time; and nothing could have been more applicable to the cravings of the human mind when the Gothic had died away and left mankind in the lurch. How could the human mind have better formed a new style than by referring to these structures? and how could we in our day behold them without believing that the men who reared them were great men, and that the age in which they lived was not a "Dark Age?" How, he asked, could they look at the works of Michael Angelo and Raffaelle, and say that they lived in a Dark Age? Why, we, who boasted that we lived in the light, were but punies compared to them. History had its tale to tell, and it was predestinated.

Mr. HAYWARD said he could not but approve of the fearless manner in which Mr. Seddon had stated his view. The entire gist of his paper lay in this consideration—what are we to do in the present day? He thought that, with a certain amount of common sense and true architectural feeling, it mattered very little what an architect studied, where all the styles were open to him. He did not mean to infer that this remark would apply in a case where a particular style only was known; but now every style was open to the student, and, in days like these, when archæological societies threw so much light on the past, it was, he held, of little consequence in what school the architect studied; for, if he had a true architectural feeling and taste for the beautiful, he would be sure to produce something which would be a step in advance. It was, he thought, only necessary to cast one's eyes around the metropolis to see that great progress had been made even within the last ten years. In many parts of London and in the suburbs odd bits of carving or an arch would be found which he believed would be the landmarks to the date of that particular development to which we were looking forward to as an improved age of architecture. There was also a taste springing up for pure and useful construction, as evidenced in the use of polished granite, fine stone, and improved metalwork. All these things afforded, in his opinion, ground for congratulation, and he thought that when a person like Mr. Seddon, who expressed his own deep-rooted opinions, came forward and expressed them boldly, he was doing a service to art.

Mr. DIGBY WYATT said, that with the conclusions arrived at in the paper he was unwilling to entirely concur: its author had not failed to render a just tribute of admiration to much of the art of the ancients. He was, he admitted, unable to trace the logical consistency of a writer who, while admitting so much, stigmatised as Dark Ages those in which an honest and most vigorous effort had been made by many of the choicest spirits the world had ever known, to preserve and adapt for use by the moderns all that they could rescue from oblivion amongst the mouldering relics of antiquity. If men were to dispassionately examine what really constituted the basis of much of the beauty of Gothic art in the thirteenth century, it would be found that Classic impressions reigned among the "*magistri operum*," not in the dogmas of Vitruvius alone, but in many technical traditions derived from Classic times. Mosaic, enamelling, the masonic art, and fresco, and other modes of applying colour, for instance, were handed onwards from the earliest period; and when they remembered how grand an addition sculpture gave to architecture in the best periods of Gothic, and the extent to which Nicola Pisano and the other great revivers of the art built upon the monuments of ancient Greece and Rome, they could form an estimate of how much Mediæval architecture was indebted to the Classic. If, for instance, the sculpture on the old monuments in the south of France were referred to, it would be found that it was not pure, because it was far removed from the source of inspiration. If, on the contrary, we approached the monuments of districts in which the more spiritual element, based as to all that was really valuable on the traditions of the antique, had prevailed, we should find the highest class of art. So too with regard to painting: those who came after the masters of the art of illumination, adopting general Mediæval characteristics, such as Fra Angelico da Fiesole or Gentile da Fabrione, Cimabue, or even Giotto, were very admirable in their way, but they never approached to the grand style of those who succeeded them. What, after all, were they to compare with Raffaelle, Leonardo da Vinci, Quini, Michael Angelo, or Titian? He confessed he was surprised to find Mr. Seddon speak in terms of disparagement of an age which produced such men. It was not enthusiasm nor feeling for art which Mr. Seddon lacked, but it was a reverent and catholic spirit that was wanting in him. It was not desire to excel, nor originality that he required, but breadth and strength, flexibility, and the power of eliminating beauty wherever it might exist, without prejudice or bias.

INSTITUTION OF MECHANICAL ENGINEERS.

Sir W. Armstrong's Address.

THE annual meeting of the Institution of Mechanical Engineers was held on July 31, at Sheffield. The President, Sir William Armstrong, in delivering the inaugural address, made the following remarks:—

"In glancing at the history of mechanical science during the last eighty years, we see how entirely our successes have been based upon the possession of that metal with which the Author of nature has supplied us in the greatest abundance. Without iron all our skill and ingenuity would have resulted in comparative nothingness; and had it not been endowed with that singular property of hardening by sudden immersion, after previous conversion into steel, we should have been deprived of the means of cutting and shaping it to those accurate forms which our mechanical constructions require. Its property of welding is almost equally essential to its utility, and the combination of these remarkable qualities in one metal, coupled with the fact of its natural localities being generally identical with those of coal, affords the most striking instance of adaptation to the purposes of man that can be found in the mineral kingdom. It is the iron, and not the golden, age which is the true age of civilisation; and England has led the way in the march of progress chiefly through her skill and energy in producing this metal, and applying it to mechanical purposes. Iron, unlike all other metals, has three phases of existence—cast-iron, wrought-iron, and steel, each equally useful, and yet so different as to be virtually separate metals. In the manufacture of steel the town of Sheffield enjoys an unrivalled eminence, and our discussions on this occasion will naturally be directed to those various questions of peculiar interest which at present apply to that most useful product.

Our warlike neighbours the French, always forward in everything appertaining to war, have of late years devoted their energies to two most important subjects—the rifling of ordnance, and the application of defensive armour to ships. Their advances have necessitated similar steps on our part, and we have certainly no reason to suppose that we are behind them in the race. With the first of these subjects I have been personally much concerned, and I have also had opportunities of observing the merits and defects of the various natures of armour plates with which experiments have been made by direction of her Majesty's government. I need scarcely say that, up to the present time, cast-iron has been almost exclusively employed in the construction of heavy ordnance; but guns made of that material have not been found adequate to resist the more severe strain incident to the use of elongated rifled projectiles. This inadequacy of strength becomes the more decided as we increase the magnitude of the gun; and since a growing demand exists for more powerful artillery, the use of cast-iron for its construction seems to be entirely precluded. It is said, and I believe with truth, that in America the manufacture of cast-iron ordnance has been so far improved, by applying water to cool the casting from the interior, as to enable serviceable guns of this material to be produced of much larger bore than have been made in England. But it appears that these guns have not been rifled, and are only intended to be used with hollow projectiles. This success therefore affords no reason for coming to a different conclusion as to the unfitness of cast-iron for the construction of rifled guns designed to project solid shot, especially when the dimensions are large. Even when strengthened by wrought-iron hoops, the tendency of cast-iron in a gun is to become weaker by every succeeding discharge. This is owing to minute fractures occurring in the bore, generally in the vicinity of the vent, and gradually extending until they terminate in the rupture of the gun. If, therefore, cast-iron guns are to be utilised at all as rifled ordnance, it can only be by confining their use to hollow projectiles and light charges; but, if the same indulgence were extended to wrought-iron guns, equal efficiency would be obtained with half the weight of metal, and on this ground alone the superiority of the latter is decisive. Wrought-iron made either from "bloom" or "puddled ball" must necessarily consist, in the first instance, of a congeries of welds or joinings. The smaller the mass, and the more it is reduced under the rolls or hammer, the more perfectly will it be united, but when a large block is forged from an aggregation of blooms it is almost impossible to render it homogeneous throughout. The flaws in such a forging will generally be drawn out by the process of hammering in the direction of the length, and will therefore not materially affect its strength in reference to longitudinal strains. But if the mass be subjected to an explosive force acting from the interior, as in a gun, the presence of such flaws becomes fatal. Wrought-iron therefore, applied as a solid block to the construction of guns, I hold to be even more objectionable than cast-iron, for although a wrought-iron gun thus made, if it happen to be sound, may possess greater powers of resistance, yet it must always be more subject than cast-iron to concealed flaws, and on that account be more uncertain and treacherous. If iron, after its conversion to the malleable form, could be fused, all welds would be obliterated, and the mass rendered uniform throughout. Such a material would merit the apellation of "homogeneous iron," but the metal which now bears that name is of a different nature, being merely a species of cast-steel. But the crystalline form assumed by steel, in solidifying from the liquid state, always renders the material in the first instance hard and brittle; and it is only under the subsequent process of hammering that it acquires ductility and toughness. This alterative process of hammering is perfectly effectual when the thickness of the steel is small, but when it is required to be forged into a large mass, it appears to be a matter of the utmost difficulty to effect the required change. It is seldom that the enterprise of English manufacturers is exceeded by that of foreigners, but in the production of steel forgings of large dimensions, Krupp, of Essen, has taken the lead of all steel makers in this country. He has met the difficulty of toughening large masses of cast-steel by using hammers of extraordinary weight, and I believe that equal success will never be attained in England without adopting similar measures. It will be a great era in metallurgy when a material possessing the toughness and ductility of wrought-iron, combined with the homogeneous character of a cast metal, can be economically supplied in large blocks. But whatever the march of improvement may effect, I doubt whether such blocks can yet be produced at a cost which would admit of their extensive application. I am glad however to see that papers are to be read at this meeting which may be expected to bear upon this important subject; and amongst the names appended to those papers we are fortunate in having that of Bessemer, whose exertions in this field of inquiry have attracted so much attention.

The preceding observations on the application of iron to the construction of artillery would not be complete without some allusion to the system of manufacture which I have myself adopted, and which may be designated the "coil system." When malleable iron is rolled into bars, its crystallisation assumes a fibrous form, causing the bar to resemble a bundle of threads strongly adhering to each other, but possessing their chief tenacity in the direction of their length. The compressive power of the rolls is also such as generally to eliminate all imperfect welds, or, if any remain, they are drawn out parallel with the fibre of the iron. To realise in a cylinder the advantage of this fibrous structure it becomes necessary to coil the bar into a spiral, and to unite the folds by welding. The lines of welding will then be transverse to the cylinder, in which direction they have little tendency to weaken it when exposed to a bursting force, even should they not be perfectly sound. There is a limit to the thickness of bar which it is convenient to bend into a spiral, and, in making a gun on this system, the required diameter is made up by applying successive layers of coils, each layer being shrunk upon the one beneath. This mode of construction has the advantage of affording the opportunity of discovering and rejecting all defective parts as the work proceeds; and guns may thus be built up to almost any size without encountering any of those difficulties and liabilities which are met with in forging large blocks, whether of steel or iron.

With regard to the great question of the ultimate effect of artillery against ships protected by defensive armour, I believe that, whatever thickness of iron may be adopted, guns will be constructed capable of destroying it. At the same time I am of opinion that iron-plated ships will be infinitely more secure against artillery than timber ships. The former will effectually resist every species of explosive or incendiary projectile, as well as solid shot, from all but the heaviest guns, which can never be used in large numbers against them. In short, it appears to me to be a question between plated-ships or none at all—at any rate, so far as line-of-battle ships are concerned. With respect to the quality of the material best adapted to resist the impact of shot, this subject is engaging much attention in the town of Sheffield, and the iron districts generally. So far as my own observation and experience go, I may say that hardness and lamination are the conditions most essential to avoid. In striking a plate, the tendency of a shot is to fracture rather than to pierce the material. When penetration is effected the hole is of a broken character, and not such as would be made by the cutting action of a punch. The softer therefore the iron, the less injury it will sustain; and I apprehend that steel in every form will, from its greater hardness, be found less effective than wrought-iron, while its cost would be very much greater. As regards lamination it has been clearly ascertained that a given thickness of iron made up of successive layers of thin plates, is very much weaker for the purpose of armour than the same thickness in the solid form. But a laminated plate, by which I mean a plate having the layers composing it imperfectly united, must be regarded as an aggregation of separate plates, so that the strength derived from continuity is wanting. If this tendency to lamination could be obviated, rolled plate would, in my opinion, be preferable to forged, since the iron would acquire a more fibrous condition, but the existence of this liability appears to turn the scale in favour of forging. I hope the time is far distant when these great questions concerning attack and defence may receive a practical elucidation in actual warfare; but I trust that, in the course of our efforts to solve them, discoveries may be made which will be as useful for the purposes of peace as for those of war.

I am tempted to advert, before I conclude, to a subject intimately connected with mechanical progress, but upon which much difference of opinion may exist. That dauntless spirit which, in matters of commerce, has led this country to cast off the trammels of protection, has resulted in augmented prosperity to the nation, showing the injurious tendencies of class legislation when opposed to general freedom of action. Would that the same bold and enlightened policy were extended, in some degree at least, to matters of invention. Under our present patent laws we are borne down with an excess of protection. We are obstructed in every direction by patented inventions, which will never be reduced to practice by those who hold them, but which embrace ideas capable of useful application if freed from monoply. The merit of invention seldom lies in the fundamental conception, but is to be found in the subsequent elaboration and in the successful struggle with difficulties, unknown to the mere theorist, and often requiring years of labour, blended with disappointment, for their removal. Nothing can be more irrational, therefore, than to give equal privileges to the mere schemer and to the man who gives actual effect to an invention. Primary ideas ought to be the common property of all inventors, and protection, if we are to have it at all, should be sparingly awarded to those persons alone who by their labours and intellect give available reality to ideas. Apart from the impolicy of our present indiscriminate system, its operation is unjust. Philosophers, who furnish the light of science to guide to useful discovery, go altogether unrewarded and unrecognised. Practical men, who, like Watt and George Stephenson, devote the best part of their lives to perfecting inventions of immense importance to the world, seldom derive from patents any greater emolument than would flow to them without the aid of a restrictive system, while they are frequently involved in tormenting litigation about priority of idea. On the other hand, we see numerous cases of disproportionate wealth realised by persons whose only merit has been promptitude in seizing upon and monopolising some expedient which lay upon the very surface of things, and required no forcing atmosphere of protection for its discovery. Finally, injustice is done by the existing law to those men who have no desire for monopoly, but who are compelled to become patentees for no other purpose than to prevent their being excluded from carrying their own ideas into practice. For my part, I incline to think that the prestige of successful invention would, as a rule, bring with it sufficient reward, and that protection might be entirely dispensed with. On this point however I speak with hesitation; but it is, at all events, certain that extensive reform is urgently required in this branch of legislation, and that the advance of practical science is now grievously obstructed by those very laws which were intended to encourage its progress.

Having now called to your remembrance the triumphs which have already been accomplished in mechanical science, and having directed your attention to some of the subjects which at the present time merit your consideration, it only remains to express my hope that the genius, enterprise, and intelligence which have hitherto distinguished your profession, may continue to bear fruits worthy of the past, and that the proceedings of this institution may serve to guide and stimulate the efforts of its members."

CHICHESTER: THE CATHEDRAL AND OTHER ANCIENT BUILDINGS.*

By Gordon M. Hills.

From Bishop Langton's time I pass over one hundred years. This includes the period of the exhausting wars with France, made brilliant by the achievements of Cressy and Poitiers,—the disastrous reign of Richard II.,—the troubles on the accession of the house of Lancaster,—renewed wars with France, including the battle of Agincourt; and brings us to the reign of Henry VI., who before the Wars of the Roses commenced was a patron of architecture. Adam de Moleynes, Bishop of Chichester from 1445 to 1449, was long keeper of the privy seal and councillor to this monarch, and may have had something to do with the later works—his connection with the see was too short to permit the supposition that he originated them. I attribute them rather to the earlier part of the reign of Henry VI., and suppose them to have been completed before the full tide of civil war set in in 1450.

If we may imagine the reasoning of the promoters of the several works belonging to this age it would perhaps amount to this: The great central tower was incomplete, *i.e.*, wanting its spire, but the dread of settlements, which had caused the respite, had ceased. As no further change had taken place, some daring and ambitious man was anxious to secure the fame of carrying the work to a completion. To make the project more safe, the bells, if they were there, must be removed from the central tower. The western towers were ill adapted to receive bells, and therefore a new belfry must be built. Thus, nearly at the same time, as I conceive, arose the spire of the cathedral and the detached belfry, popularly called Ryman's Tower. To the spire I give some preference in point of time. The early mouldings were continued up the angles, two bands of ornament which encircled the spire very plainly fix its date at the early part of the fifteenth century, and the pinnacles and canopies grouped round its base belonged to the same age, and bore very distinct marks of insertion into older work, thus justifying my idea that the base of the spire had been commenced long before. Of Ryman's Tower there is a popular legend as to its origin, and this legend is not without authoritative support. The name is that of a family long settled at Appledram, a village two miles to the south of the city; and one of them, it is said, intending to build a house or castle for himself, collected a quantity of stone. King Edward III. refused him permission to possess a fortified mansion, and the Bishop of Chichester purchased the materials he had prepared. The king's inhibition is well established; moreover, there is at Appledram a part of an ancient crenellated mansion, now used as a farm-house, and the stone of the belfry tower is different in kind from any used elsewhere in the cathedral precinct; in date the two buildings agree; their age is however later than the time of Edward III., as I have already pointed out with respect to the belfry.

Not before, and it may be later than this time, an alteration took place in the north transept; an immense Perpendicular window was inserted in the end, to correspond with Langton's window in the south transept. It is very inferior to it in beauty, and seems to have weakened the end of the transept so seriously, that it became necessary to buttress it sideways with a large flying buttress, which itself has yielded considerably to the pressure.

An important work which belongs to this age, although we have no authority beyond architectural features to guide us as to date, is the cloister. Bishop Langton's cloister disappeared entirely, and with it his chapter-house; and the builders of the fifteenth century gave us a complete cloister of their own age, yet leaving evidences of an older one; and raised a new chapter-house on the top of the ancient sacristies, to the west of the south transept. This cloister and chapter-house have come down entire to our own day. The chapter-house yet retains some of its oak seating and panelling; some of it, we are expressly told, was destroyed by the Parliamentary soldiers, who tore it down in search of treasure. The stall or state chair for the presiding dignitary yet remains, and close to it a sliding panel in the wainscot discloses a massive oak door, strongly bound with iron, which opens into a space over the south part of the cathedral, and which formed the treasury. For access to this chapter-house stair was cut in the transept wall, which makes us wonder hardihood of the builders, who, having placed a spire on the already weakened Norman legs, yet ventured to weaken the wall which supported them. I hesitate to attribute to builders of that age a yet more reckless act, and yet must admit that there is evidence against them; and if it were possible to make it conclusive it would show that the complete state at which we have seen the cathedral arrive was marked by a singular carelessness on the part of the builders who ought to have preserved it. Under Bishop Arundel, who presided from 1459 to 1478, was erected at the west end of the nave a screen, intended to be used as a chantry, and designated in the Liber Regis of 1535, "Cantaria Johannis Arundell Epi. ad ostium chori." Before his time the shafts under the east and west arches of the tower had been cut away for a height of 12 feet, to widen the space of the choir stalls. Arundel's screen just touched on the western angles of the two western tower piers, and some portion of the face of the piers was further concealed by stone stairs, giving access to the top of the screen, and placed between the screen and the stalls. On the removal of the screen and fittings last year, not only was it perceived that the tower piers were more seriously rent than was before known to be the case, but a piece of one of them was entirely cut away at the base, and an important part of the superincumbent work carried upon two slight oak props.

Bishop Sherborne, who resigned the see in 1534, and died two years after at the advanced age of ninety-six, is the last prelate whose celebrity is connected with the fabric of the cathedral. In liberality he was not surpassed by any of his predecessors, but the exercise of it was directed to the addition of painting, gilding, and ornament, generally far more gorgeous than tasteful. To his munificence we have owed the possession of those singular decorations, the historical pictures in the south transept. They were painted by Theodore Bernardi, upon oak panels, and depicted on one side the foundation of the see at Selsey, and the confirmation of its privileges by Henry VII. and Henry VIII.; with a portrait catalogue of the kings of England. On the other side was a similar catalogue of the bishops of Selsey and Chichester. Under several of the portraits the inscriptions recorded events connected with the construction of the cathedral. The paintings had been more than once recoloured, and could not therefore be regarded as original productions. A large part of the catalogue of the kings, and the two large historical pictures, were destroyed by the fall of the spire. The catalogue of the bishops however sustained but little injury; neverthelesss, during the short time that they remained exposed afterwards, it became evident that the exposure would soon destroy them. The whole have consequently been taken down with care, and with the intention of re-erecting them hereafter, an intention which the state of decay of the woodwork may after all frustrate. The inscriptions referring to the fabric were these:—

Radulphus primus re-edificavit ecclesiam Cicestr. igne combustam.

Seffrid secud. re-edificavit ecclesiam Cicestren. igne secundo combustam et domos suas in palacio Cicestren.

Radulphus secund. multa huic fecit eccl'iæ et Epatui construxit capellam S. Michaelis extra portam orientalem.

Gilbertus epus. de Sancto Leofardo construxit a fundamentis capellam B. Mariæ Virginis in eccl'iæ Cicestren.

Johannes tertius dictus de Langton ædificavit magnam sumptuosam fenestram australem ecclesiæ Cicestrensis.

Adam Molens dedit eccl'iæ panos et serico velveto factos rubii coloris non minoris pretii ad ornandu altare sumu.

Edwardus Story sacre. theol. prof. fecit ædificari novam crucem in mercato Cicestr.

Robertus Sherborne x' x' suam eccl'iam cathem. Cicest. multo decore magnifice adornavit.

From hence we have only to note the decline of the structure. The first information of its subsequent state with which I am acquainted shows however some appendages, which, if they really existed, enhance the dignity of the cathedral—namely, two western spires. The only authority for this is, however, a small but well executed view on Speed's map of 1610. Although the view is generally faithful, I must discover some confirming authority before I can consider it established that these spires really existed. The neglect with which the building soon came to be treated may be gathered from Archbishop Laud's instructions to the dean in 1635. He requires the building to be put in repair, and that "the paradise within the cloisters, theretofore a burial-place, and then, by reason of a lease of his (the dean's) predecessors, converted into a private garden, shall be by some fair means restored and reduced to its pristine and consecrated use." The dean was Richard Stuart, a man of considerable eminence, and in favour with Charles I. He no doubt seconded the desires of the archbishop, and it would appear that some repairs to the top of the spire were effected in his time, as we find his name, with those of the contemporary canons, engraved on the copper weathercock now so lately thrown to the ground. It also bears the inscription, "Daniell Seymor Goldsmith, made t'is December 1638." Further inscriptions upon it testify to repairs in 1675 and 1698.

---

* Concluded from page 249.

Immediately after Dean Stuart's time came the Great Rebellion. The historians of the city have certainly attributed to the fanatical puritans far more of active destruction than I can find it just to lay to their charge. I have already pointed this out with respect to the parish churches. It is commonly believed, on the authority of Hay and Dallaway, that Sir W. Waller's batteries destroyed the north-west tower of the cathedral. Contemporary accounts show that his first battery was upon the Broil to the north of the city, probably too far off to have done any serious damage to this building. The second battery was planted in Cawley's Almshouse (the present workhouse), 300 yards in front of the north gate of the city, and from this point the north-west tower was completely covered and protected by the belfry-tower, which itself bears no signs of battering. It must have covered it almost equally from the position of the first battery. There was a vigorous assault at the west gate, but no breaching artillery was used there, and the damage to the buildings outside arose probably quite as much from the measures of the defenders as from the efforts of the assailants. This was the point from which the tower was most likely to have suffered. But the Dean Bruno Ryves, who himself gave an account of the proceedings of the rebels (in 'Mercurius Rusticus') makes no allusion to any such destruction, and speaks only of the wanton damage done by the soldiery within the cathedral to the monuments, pictures, and fittings, after the surrender of the city. A second visitation for the purpose of wilful destruction, which is said to have taken place under Sir A. Haselrig, proves on examination to have been the same with the first, this officer serving then under Waller; and his share in the spoliation being the pillage of the cathedral treasury, as stated by Bruno Ryves, six or seven days after Waller's men had fulfilled their mischievous mission; a treacherous officer of the cathedral having given him notice where the plate was deposited. In the account of Bruno Ryves we also have proof that the Subdeanery church (or St. Peter the Great) then formed an integral part of the cathedral, which bears out what I have already said on that subject. "Having made what spoyle they could in the cathedral," he says, "they rush out thence and breake open a parish church standing on the north side of the cathedral, called the Subdeanry."

After what I have now said of the north-west tower, we may take Hollar's engraving, made for Dugdale at the expense of the bishop in 1673, as positive proof of its state at that period. According to his drawing of the north side of the cathedral.the tower in question was then perfect, and strictly like the south-west tower. I must own however that there is a plate by one Daniel King, which—although he was a pupil of Hollar's—may (according to Walpole's 'Engravers') be as early as 1656, and, if so, it throws some doubt on Hollar's accuracy. It appears to belong to King's work on cathedral and conventual churches; I have only seen this single plate, but cannot avoid thinking that Walpole is in error as to date, and that, as his pupillage would suggest, the view is later than Hollar's; when it was taken, the outer or north-west angle of the tower in question had fallen out from top to bottom. Willis's 'Abbeys' (1719), in furnishing the dimensions of Chichester cathedral, has, "height of *towers* at west end, 95 feet." Stukeley's view, 1723, shows the tower standing; Buck's view, 1738, shows the north side of the tower wholly fallen out. Further decay may be traced in subsequent views, until, some time before 1780, the remnants of the tower appear to have been taken down and reduced to the form in which they exist at the present day. Extensive repairs, though their nature is not stated, were executed at the cathedral in 1791. Twenty-five feet of the summit of the spire was rebuilt in 1814, when the battlements at the top of the tower were also renewed. In 1818 some extensive re-arrangements were made in the interior, by no means to the advantage of the building, fixed pews being substituted in the nave for movable seats; about ten years later all this was again swept away, the nave abandoned, and the service confined to the choir. On one of these two last occasions, two doorways were cut in the back of the Arundel screen, and some alterations were made in the stairs behind it. I cannot say precisely what was done here now; but it is quite possible that, after all the reckless cutting away of the tower pier, it may at least have been placed in its worst condition at this time. From that occasion down to the year 1859 nothing has been done which affected that part of the structure.

In the autumn of that year the well-known architect, Mr. Slater, was charged with the duty of opening out the choir to the nave, to increase the space for divine service, the project being in accordance with the long-cherished desire of Dr. Chandler, the late dean, and aided by a bequest from him of £2000. The old stalls were to be taken down for repair, and the Arundel screen and stairs behind it wholly removed. According to the published statement of the architect, the removal of these fittings exposed to view a state of decay in the lower parts of both the western piers which had not been anticipated. Large and important parts of the masonry were entirely separated from the piers by cracks and fissures, and the destructive cutting into the south-west pier, previously spoken of, was brought to light. Under the circumstances, and after taking fresh professional advice, it was determined to rebuild the detached portions, and bind them effectually to the old work—a process which was carried out to a very large extent in the north-west pier, and in a much less degree in the south-west pier, these operations being conducted during the summer of 1860. Some minor repairs to the other two piers were not completed till February of the present year.

It cannot now be doubted that the piers were already too weak to bear these operations. The new work in the western piers began to show signs of failure soon after its completion. The signs increased, but so slowly as not to excite apprehension in those who saw them from day to day, and to whom therefore the change was not apparent,—the crack which was observed not having opened so much as the eighth of an inch in three months. At the end of January in the present year, the true character of the warning began to be appreciated, which led to the preparation of additional supports to those which had been already erected for safety's sake whilst the work was proceeding, and to the suspension of all work in the building which could have any tendency to shake or jar the trembling piers. On the 15th of February the crushing of the tower piers under the weight of the lofty tower and spire had advanced so decidedly, that it was felt that most energetic exertions must be used to keep them in their place and relieve them of weight. The measures were taken without delay, and all the force employed that could be made available. The result is well known. All efforts proved too little for the emergency. and at half-past one on Thursday, the 21st of February, the whole tower and spire fell in the centre of the building, a quarter of an hour after the workmen had been withdrawn from the work.

So great a calamity has not befallen the structure since the days of Seffrid the Second. We hope, and believe too, that our own generation will not be surpassed by Seffrid and his coadjutors in the heartiness and vigour with which the work will be replaced, and in far better condition than before. Encouraging proofs of determination in this respect are already produced in the subscription in the neighbourhood of half the sum required for the rebuilding; and, in full hope of realising the remainder, the work of restoration has already been commenced.

ON THE MANUFACTURE OF STEEL, AND ITS APPLICATION TO CONSTRUCTIVE PURPOSES.[*]

By Henry Bessemer.

The mode of manufacturing cast-steel, which now forms so important a branch of the Sheffield trade, was discovered in the year 1740, by Mr. Benjamin Huntsman, of Handsworth, near Sheffield. This gentleman subsequently established steel works at Attercliffe, where his most valuable invention has ever since been successfully carried on. In the early stages of this invention many difficulties had doubtless to be overcome: materials for the lining of furnaces and for the making of crucibles had to be sought for and tested; the peculiar marks of iron most suitable for melting had to be determined on by numerous experimental trials; and such was the difficulty at that time of making crucibles that would stand the excessive heat of molten steel, that only very highly carbonised, or "double converted" steel, could for a long period be successfully melted.

---

[*] From a paper read at the Institution of Mechanical Engineers.

The first products of a new manufacture, even while the invention still remains in a partially developed state, but too frequently stamps its subsequent character: thus Huntsman's cast-steel, although it was acknowledged to be a pure homogeneous metal, of great value for certain purposes, was still looked upon as a hard and brittle material, of very limited use, not bearing a high temperature without tumbling to pieces, and quite incapable of being welded. Even within our own time this has been the popular idea of cast-steel. Improvements in its manufacture have however from time to time been introduced, and steel of a milder and less brittle character has long been made capable of welding with facility and working at a high temperature without falling to pieces. Its uses have in consequence been greatly extended, and the employment of cast-steel for the best cutlery and edge tools has now become universal; indeed, the excellent quality of the cast-steel at present made in Sheffield for these purposes is scarcely to be surpassed. Of late years several of our most enterprising manufacturers have sought to introduce cast-steel for a variety of purposes other than those for which it was originally employed; hence we now find it used in some form or other in almost every first-class machine. Its employment as a material for founding bells and various other articles in clay moulds has been successfully carried out by Messrs. Naylor, Vickers and Co., while the introduction of a most valuable material by Messrs. Howell and Shortridge, under the name of homogeneous iron, are prominent examples of the successful adaptation of cast-steel to engineering purposes.

The manufacture of cast-steel by Huntsman's process is so extensively practised, and is so well known, that it will not be necessary here to go into any lengthened detail; but it may be as well to remind those who have not paid special attention to the subject, that crude pig iron has first to go through all the stages of melting, refining, puddling, hammering, and rolling, in order to produce a bar of malleable iron as nearly pure as the most careful manipulation in charcoal fires can make it.

Bar iron, on which so much labour, fuel, and engine-power has been expended, thus becomes the raw material of this most expensive manufacture. In order to convert these iron bars into blister steel they are packed with powdered charcoal in large chests, and are exposed to a white heat for several days: the time required for heating and cooling them extending over a period of twenty days. The iron bars, when thus converted into blister steel, are broken into small pieces, and are sorted for quality, which sometimes differs even in the same bar. For melting this material powerful air furnaces are employed, containing two crucibles, into each of which are put about 40 lb. of the broken blistered steel: in about three hours the pots are removed from the furnace, and the molten steel is poured into iron moulds, and is thus formed into ingots of cast-steel; from 3½ to 4 tons of hard coke being consumed for each ton of metal so melted. When large masses of steel are required, a great many crucibles must be got ready at the same moment, and a continuous stream of the molten metal from the various crucibles must be kept up until the ingot is completed, as any cessation of the pouring would entirely spoil it. Hence, in proportion to the size of the ingot, so is the cost and risk of its production increased.

From the foregoing remarks it will be obvious that the cast-steel manufacturer is working at an immense disadvantage. If he desires to supersede the use of wrought-iron for engineering purposes he must cease to employ wrought-iron as a raw material for his otherwise most expensive mode of manufacture. The extremely high temperature requisite to maintain malleable iron in a state of fusion has, from the earliest period of the history of iron up to almost the present day, rendered its purification in a fluid state practically and commercially impossible. Hence arise all those imperfections to which bar iron is subject, every small piece of this material consisting of numerous granules partially separated from each other by scoria, and every large mass of it resulting only from the piling together of small bars, with the inevitable result of increasing the former imperfections; for no two pieces of iron can be brought to a welding heat without becoming perfectly coated with oxide, and when this coating is rendered fluid by welding sand a fluid silicate of the oxide of iron is formed, covering the entire surface to be united. The heavy blows of the hammer or the pressure of the rolls may, and does [illegible] e greater portion of this fluid extraneous matter, but it is never wholly removed from between the welded surfaces: hence a portion of the cohesive force of the metal is lost at every such junction. When a bar of iron is nicked on one side, and bent, the rending open of the pile clearly shows this want of perfect cohesion; nor is this the only difficulty to be encountered, for in the production of large masses of wrought-iron it is necessary to raise the temperature nearly to the fusing point of the metal, in order to render each additional piece sufficiently soft and plastic to become united to the bloom. This softening of the iron induces a molecular change in the structure of the metal—its natural tendency to crystallise is so powerfully assisted by the long continuance of this high temperature, that its whole structure undergoes a change. Large and well-defined crystals are formed almost independent of each other, and cohering so feebly to the planes of other contiguous crystals as in some cases to separate with as little force as would overcome the cohesion of ordinary cast-iron.

In the substitution of cast-steel for malleable iron we escape both these sources of difficulty, for the mass, whether it be of 1 ton or 20 tons in weight, may be formed in a fluid state into a single block, wholly free from an admixture with scoria, while it is perfectly and equally coherent at every part. The forging into form of such a solid block of metal is only the work of a few hours, and as there is no welding of separate pieces it may be worked under the hammer at a temperature at which no molecular disturbance will take place, the metal being far below its fusing point, and much too solid to undergo that destructive crystallisation so common in large masses of iron. Thus it will be perceived that the difficulties and uncertainty which attend the production of all large masses of wrought-iron are wholly avoided in the production of equally large masses of cast-steel. But however desirable in the abstract it may be to employ cast-steel as a substitute for malleable iron for engineering purposes, it must not be forgotten that there are several important conditions indispensable to its general use. Firstly, the steel must be able to bear a good white heat without falling to pieces under the hammer, or otherwise the shaping of it will not only be expensive, but the partly-finished forging may be spoiled at any moment by being over-heated. Secondly, the steel should be of that tough character as to admit of being twisted or bent almost into any form in its cold state before fracture takes place, whether the force be applied as a gradual strain or by sudden impact. Thirdly, it should have a tensile strength of at least 50 per cent. over the best marks of English iron. Fourthly, and especially, it must be soft enough to turn well in the lathe, to bore easily, and to yield readily to the file and the chisel, so as not to enhance its original cost by the difficulty of working it into the required forms. This is both practically and commercially an important question, and one which will in future greatly determine the extent of its use. Steel to the engineer has hitherto stood in much the same relation as granite to the builder. All acknowledge the superior hardness, beauty of polish, and durability of that material as compared with other building stone: Nature has given it to us in great profusion,—we have only to lift it from the earth and use it. But the practical man has found that to drill a hole in granite for blasting takes days of labour to accomplish, blunts all his chisels, defies the saw, and is only faced at a great cost: hence the builder goes on using his inferior soft stone, over which his tools have perfect command.

The problem we have before us is, how to produce cast-steel that will take any form in the mould or under the hammer; that will yield quickly and readily to all our present cutting and shaping machines; will retain all the toughness of the best iron, with a much greater tensile strength, and all the clearness of surface, beauty of finish, and durability that so eminently distinguish the harder and more refractory qualities of the steel in common use. It is believed by the author that these desirable objects are fully accomplished by his process of converting crude molten iron into cast-steel at a single operation, which process has now been in daily operation for the last two years. For this purpose the hematite pig iron, smelted with coke and hot-blast, has chiefly been used. The metal is melted in a reverberatory furnace, and is then run into a founder's ladle, and from thence it is transferred to the vessel in which its conversion into steel is to be effected. It is made of stout plate iron, and lined with a powdered silicious stone, found in the neighbourhood of Sheffield, below the coal, and known as ganister. Its value in the powdered state is about 11*s.* per ton. The rapid destruction of the lining of the converting vessel was one of the great difficulties met with in the early stages of the invention; the excessive heat generated in the vessel, together with the solvent action of the fluid slags, were found to dissolve the best fire-brick so rapidly, that sometimes as much as 2 inches in thickness would be lost from the lining of the vessel during the thirty minutes required to convert a single charge of iron into steel. The material used at present is much cheaper than fire-bricks, and is also very durable. The old lining of the vessel shown has stood ninety-six consecutive conversions before its removal. The converting vessel is mounted on axes, which rest on stout iron standards, and by means of a wheel and handle it may be turned into any required position. There is an opening at the top for the inlet and pouring out of the metal, and at the lowest part are inserted seven fire-clay tuyeres, each having five openings in them; these openings communicate at one end with the interior of the vessel, and at the other end with a box called the tuyere box, into which a current of air from a suitable blast engine is conveyed under a pressure of about 14 lb. to the square inch, a pressure more than sufficient to prevent the fluid metal from entering the tuyeres.

Before commencing the first operation, the interior of the vessel is heated by coke, a blast through the tuyeres being used to urge the fire. When sufficiently heated the vessel is turned upside down, and all the unburnt coke is shaken out. The molten pig iron is then run in from the ladle before referred to; the vessel during the pouring in of the iron being kept in such a position that the orifices of the tuyeres are at a higher level than the surface of the metal. When all the iron has run in, the blast is turned on, and the vessel quickly moved round. The air then rushes upwards into the fluid metal from each of the thirty-five small orifices of the tuyeres, producing a most violent agitation of the whole mass. The silicium, always present in greater or less quantities in pig iron, is first attacked: it unites readily with the oxygen of the air, producing silicic acid, at the same time a small portion of the iron undergoes oxidation, hence a fluid silicate of the oxide of iron is formed, a little carbon being simultaneously eliminated. The heat is thus gradually increased until nearly the whole of the silicum is oxidised; this generally takes place in about twelve minutes from the commencement of the process. The carbon now begins to unite more freely with the oxygen of the air, producing at first a small flame, which rapidly increases, and in about three more minutes from its first appearance we have a most intense combustion going on: the metal rises higher and higher in the vessel, sometimes occupying more than double its former space. The frothy liquid now presents an enormous surface to the action of the oxygen of the air, which unites rapidly with the carbon contained in the crude iron, and produces a most intense combustion,—the whole, in fact, being a perfect mixture of metal and fire. The carbon is now eliminated so rapidly as to produce a series of harmless explosions, throwing out the fluid slags in great quantities, while the union of the gases is so perfect that a voluminous white flame rushes from the mouth of the vessel, illuminating the whole building, and indicating to the practised eye the precise condition of the metal inside. The workman may thus leave off, whenever the number of minutes he has been blowing and the appearance of the flame indicate the required quality of the metal. This is the mode preferred in working the process in Sweden. But here we prefer to blow the metal until the flame suddenly drops, which it does just on the approach of the metal to the condition of malleable iron; a small quantity of charcoal pig iron, containing a known quantity of carbon, is then added, and steel is produced of any desired degree of carburation; the process having occupied about twenty-eight minutes from the commencement. The vessel is then turned, and the fluid steel is run into the casting ladle, which is provided with a plug rod covered with loam; the rod passes over the top of the ladle, and works in guides on the outside of it, so that by means of a lever handle the workman may move it up and down as desired. The lower part of the plug, which occupies the interior of the ladle, has fitted to its lower end a fire-clay cone, which rests in a seating of the same material let into the bottom of the ladle, thus forming a cone valve, by means of which the fluid steel is run into different sized moulds as may be required, the stream of fluid steel being prevented by the valve-plug from flowing during the movement of the casting ladle from one mould to another. By tapping the metal from below no scoria or other extraneous floating matters are allowed to pass into the mould.

By this process from one to ten tons of crude iron may be converted into cast-steel in thirty minutes, without employing any fuel except that required for melting the pig iron and for the preliminary heating of the vessel, the process being effected entirely without manipulation. The loss in the weight of crude iron being from 14 to 18 per cent. on English iron worked in small quantities, the result of working on a purer iron in Sweden has been carefully noted for two consecutive weeks, when the loss on the weight of fluid iron tapped from the blast furnace was ascertained to be 8¾ per cent. The largest sized apparatus at present erected is that in use at the Atlas Steel Works, the vessel being capable of operating on 4 tons at a time, which it converts into cast-steel in twenty-five minutes. In consequence of the increased size of the vessel no metal is thrown out during the converting process, and the loss of weight has fallen as low as 10 per cent., including the loss in melting the pig iron in the reverberatory furnace.

On the table before you are some examples of this manufacture as carried on by Messrs. Henry Bessemer and Co. The first sample is a piece of the pig iron employed—viz. hot-blast coke-made hematite No. 1. Secondly, a portion of an ingot of very mild cast-steel, broken under the hammer, to show the purity and soundness of the metal in its cast unhammered state. Perfectly sound ingots of such mild steel are extremely rare, if ever produced by the old process. The third example is an ingot partly forged, to show how little work with the hammer will produce a forging from these solid blooms of steel.

There are also two pieces of steel of the quality employed for making piston-rods: these samples were bent cold under a heavy steam-hammer. To show the toughness of the metal, it requires very much more force to bend it than would be required to bend wrought-iron, but notwithstanding this additional rigidity, it gives to any extent without snapping. The tensile strength of this soft and easily-wrought metal is from 41 to 43 tons per square inch, or from 15 to 18 tons greater than Lowmoor or Bowling iron. In turning, planing, boring, and tapping this metal, it will be found that the uniformity of its quality will be less trying to the cutting tools than the hardvanes and sand-cracks found in the common qualities of malleable iron. It must however be borne in mind, that the tensile strength of the piston-rod steel just quoted is by no means the maximum, but, on the contrary, it is nearly the minimum strength of such converted metal; at the same time, it possesses nearly a maximum degree of toughness—every additional ton in tensile strength given to it by the addition of carbon hardens it for working, renders it more difficult to forge, and brings it nearer to that undesirable state when a sudden blow snaps it like a piece of cast-iron.

The extreme limits of tensile strength of the converted metal are exhibited in a tabular form on the wall above. They are the result of many trials made at different times at the Royal Arsenal at Woolwich, under the superintendence of Col. Eardley-Wilmot, and are copied from his reports. The highly-carbonised samples exhibit a mean tensile strength of 152,000 lb., and are from their hardness and unyielding nature totally unfit for many purposes; while the entirely decarbonised metal is so soft and copper-like in its texture as to yield to a mean strain of 72,000 lb., a point unnecessarily low, except in cases where a metal approaching copper in softness is required. The author therefore is strongly impressed with the belief that the soft, easy-working, tough metal, of the quality used for piston-rods, is the most appropriate material for general purposes; and that the hard steels, that range up to a tensile strain of 50 or 60 tons per square inch, should be avoided as altogether too expensive to work, and too dangerous to be employed in any case where sudden strains may be brought upon them.

With reference to the employment of cast-steel for constructive purposes, there are few of more importance than its recent and successful application to the making of steam boilers. The Cornish boiler, as improved by Mr. Adamson, of Hyde, near Manchester, has a large flue-tube constructed with narrow plates, which are over 12 feet in length, and flanged at each edge in a manner that, while it adds greatly to the stability of the tube, demands such qualities in the material employed for its manufacture as are only found in metal that has undergone fusion and has become perfectly homogeneous throughout.

As a practical illustration of this mode of constructing boilers, and of the great strain which the Bessemer steel is capable of sustaining safely, we may refer to the steam boilers employed for some time past at the works of Messrs. Platt Brothers, of Oldham, where six of these boilers are in daily use, their length being 30 feet, diameter of shell 6 ft. 6 in., diameter of flue tube 4 feet, thickness of plates $\frac{5}{16}$-inch, working pressure 100 lb. per square inch. The advantages of cast-steel are still more marked in the construction of the fire-boxes of locomotive engines. The difficulty of flanging and shaping these pieces in plate iron without splitting the metal in some part is so great as to have hitherto rendered the employment of copper necessary for this purpose; but the shape required can now be obtained with ease and certainty by hammering up a sheet of metal rolled from an ingot, such as that on the table before you. One of these plates flanged by Mr. Adamson is also shown, and clearly illustrates the facility with which the metal may, under skilful hands, be wrought into any required form.

The perfect continuity of the material, its entire absence from joinings or weldings, also obviously mark it out as specially suitable for the tube-plate of locomotive engines. However near the holes are made to each other there is no danger of their having a flaw or other weak place between them. In many instances the rivet-holes have been punched so close, as to remove almost all the metal without splitting the narrow piece still left between them. Nor is it in the construction of the boiler alone that the locomotive engine seems to demand the employment of cast-steel; the axles, whether plain or cranked, the piston-rod and its guide-bars, and last, but not least, the wheel tires, are all and each exposed to so much abrasion, and to such sudden and powerful strains, that a tough, strong material capable of withstanding this destructive wear and tear is imperatively demanded in the construction and economical working of this splendid example of engineering skill.

In pointing out a few of the more prominent and obvious applications of cast-steel to constructive purposes, it may be interesting to put on record one of its most special adaptations, the pursuit of which was, for the first year of the author's researches on iron, the sole object of his labours, and one that has throughout the last six years never been lost sight of by him. This object, it is almost needless to say, was the production of a malleable metal peculiarly suitable for the manufacture of ordnance.

By means of the Bessemer process, solid blocks of malleable metal may be made of any required size, from 1 to 20 or 30 tons in weight, with a degree of rapidity and cheapness previously unknown. This metal can also, with the utmost facility, be made of any desired amount of carburation and tensile strength that may be found most desirable. Commencing at the top of the scale with a quantity of steel that is too hard to bore, and too brittle to be used as ordnance, the metal can with ease and certainty be made to pass from that degree of hardness by almost imperceptible gradations downwards towards malleable iron, becoming at every stage of carburation more easy to work, and more and more tough and yielding, as the quantity of carbon is reduced, until it at last becomes pure decarbonised iron, possessing a copper-like degree of toughness not found in any iron produced by puddling. Between these extremes of temper the metal most suitable for ordnance must be found, and all are equally cheap and easy of production.

From the practice now acquired of forging steel ordnance at the works of Messrs. Bessemer and Co., it has been found that the most satisfactory results are obtained with metal of the same description as that employed for making piston-rods. With this degree of toughness the bursting of the cannon becomes almost impossible, its power of resisting a tensile strain being at least fifteen tons per square inch above that of the best English bar iron. Every gun before leaving the works has a piece cut off the end, which is roughly forged into a bar 2 inches by 3 inches in section, and bent cold under the hammer. In order to show the state of the metal after forging, several test bars, cut from the ends of guns recently forged, are exhibited. The power of this metal to resist a sudden and powerful strain is well illustrated by the piece of gun metal before us. It is one of several tubular pieces that were subjected to a sudden crushing force at the Royal Arsenal, Woolwich, under the direction of Col. Eardley-Wilmot. These tubular pieces were laid on the anvil block in a perfectly cold state, and were crushed flat by the falling of the steam-hammer. Neither of the tubes so tested exhibited any signs of fracture. Perhaps the best proof of the power of such metal to resist a sudden and violent strain was afforded by some experiments made at Liege, by order of the Belgian government, who had one of these guns bored for a 12 lb. spherical shot, and made so thin as to weigh only 9 cwt. 1 qr. 6 lb. This gun was fired with increasing charges of powder, and an additional shot after each three discharges, until it reached a maximum of 6 lb. $11\frac{1}{2}$ oz. of powder, and eight shots of 12 lb. each, the shots being equal to about one-tenth of the weight of the gun. It stood this heavy charge twice, and then gave way at about one metre from the muzzle of the gun, probably owing to the jamming of the shots. It is needless to state that the employment of guns so excessively light, and charges so extremely heavy, would never be attempted in practice.

It may afford some idea of the facility of this mode of making cast-steel ordnance when it is stated that the 18-pounder gun before us, having been made for the author's private experiments on gunnery, he was present, and noted the time employed in its fabrication. The molten cast-iron was tapped from the reverbatory furnace at 11.20 a.m., and converted into cast-steel in thirty minutes, the ingot being cast in an iron mould 16 inches square by 4 feet in length. It was forged while still hot from the casting operation. By this mode of treating ingots the central parts of them are sufficiently soft to receive the full effect of the hammer. At 7 p.m. the forging was completed, and the gun ready for the boring mill. The erection of the necessary apparatus for the production of steel by this process, inclusive of the air-pumps and steam-engine on a scale capable of producing from crude iron enough steel to make forty of such gun blocks per day, will not exceed a cost of £5000. Hence the author cannot but feel that his labours in this direction have been crowned with entire success, the great rapidity of production, the cheapness of the material, its strength and durability, all point to its obvious adaptation to the construction of every species of ordnance.

To the practical engineer enough has been already said to show how important is the application of cast-steel to constructive purposes. A dozen new uses for it will present themselves to his mind now that he has shown how this valuable material may be both cast and forged with such facility, and at a cost so moderate to produce, by its superior durability, and extreme lightness and economy in its use, as compared with iron. The construction of girders, bridges, and viaducts, are all subjects deserving his careful attention and study. The author was long ago impressed with the importance of its employment for marine-engine shafts, cranks, screw-propellers, anchors, and railway wheels, which, indeed, formed the subject of separate patents granted to him six years ago; and to these special applications of cast-steel the intelligent engineer will now add a host of others equally novel and important, for the author feels assured that the manufacturer of cast-steel has only to produce at a moderate cost the various qualities of steel required for constructive purposes, to insure its rapid introduction; for we may be assured that, so certain as the age of iron superseded that of bronze, so will the age of steel reign triumphant over iron.

(Mr. Bessemer exhibited a muzzle-loading cannon cast from his steel, also numerous specimens of the metal worked into various shapes, and bent and twisted to show the great strength and toughness of the material.)

◆

York Minster.—The London Warming Company have contracted, for £645, to furnish and erect twelve stoves in York Minster, four in the crypt, two in each of the choir aisles, and two in each of the side aisles of the nave. With these the company guarantee to maintain a uniform heat of 50 degrees; the power however being reserved to the contractors, if it be found necessary, to furnish and fix four extra stoves, at a cost of £30 each. If, at the end of a year, there should be a failure of the agreed temperature, the contractors are bound to remove the whole of the stoves, and the Dean and Chapter are to pay to them £145 for the expenses incurred in the attempt to warm the edifice. Little doubt however is entertained by the contractors as to the successful carrying out of the scheme; even though there are difficulties to surmount in connection with the minster which have not been met with in other buildings, from the large amount of window surface which it contains. The invention, which is Mr. Goldsworthy Gurney's, has already been applied in St. Paul's Cathedral, the Houses of Parliament, the Cathedrals of Limerick and Llandaff, &c. The stoves for the minster each weigh about one ton and a half, but are nevertheless portable, so that they can be removed without difficulty, should it be deemed necessary, during the summer months. They are constructed to hold five bushels of coke (though coal may also be used), which quantity, it is said, will work well for 48 hours without any attention.

REVIEWS.

Church and Conventual Arrangememt. By Mackenzie E. C. Walcott, M.A., F.S.A., &c.—London: Atchley & Co.

The paper on the above subject, read before the Institute of British Architects in January last by the Rev. M. Walcott (and from which we made extracts in our number for that month) has amplified under the well-known industry of that gentleman into a very interesting and instructive book, bearing the same title, united with a number of illustrative plans, a glossary of terms prevalent in mediæval charters and chronicles, notes, index, &c.

Beginning, as in the case of the paper above alluded to, with what is really the beginning of the subject, "the upper chamber" at Jerusalem (Acts i. 13), Mr. Walcott's book traces from thence the various forms and peculiarities of arrangement in Christian churches in all countries down to our own day; the references to existing example, and to authoritative record where the former does not now exist, in illustration of his observations, being ample and sufficient.

Of the earliest forms and appearances, both in Eastern and Western Christendom, the original or promoting causes thereof, and the gradual development of the same into the succeeding and later, our former notice gives the principal points noticed by Mr. Walcott, very nearly in the words of the present work. It will be unnecessary therefore to recapitulate in this respect. A summary of the different divisions or heads under which his remarks on this portion of his work are classed will be sufficient here, as an introduction to the consideration and clearer understanding of such as relate to succeeding erections, and their distinctive marks and changes, on which he afterwards enters in a very detailed and comprehensive manner.

Proceeding, as before observed, from the primeval and simple upper chamber, Mr. Walcott notices as the first form, the oblong, enjoined in the apostolical constitutions of the fourth century. Next noticing the alteration consequent upon the conversion of temples into churches, he refers to the Temple of Jerusalem as forming the prevailing model for the churches of the East, as was evidenced in a church built at Tyre A.D. 315-322, and correspondingly in several other churches from this period.

From this type he proceeds to observe upon the Byzantine style, which he describes as "the lineal descendant of Roman architecture, modified by the introduction of an Eastern element, which, before the reign of Constantine, had adopted a domical and vaulted form in place of the columnar arrangement of the Greek." Our author, quoting Mr. J. M. Neale ('Ecclesiologist,' ix. 7), divides this style into four periods:—the first comprising from A.D. 330 to 537, that is, to the erection of St. Sophia,—churches being within this period generally round or octagonal. The second period from A.D. 537 to 1003, viz. "to the erection of the Cathedral of Cutais, when the domes were multiplied;" the third, from A.D. 1003 to 1453, the fall of Constantinople; and the fourth, from A.D. 1453 to the present time. The arrangements of these periods, he says, were one or the other of three kinds, which are given in our former notice. Dilating upon these, and referring to the influences of the combination of the third arrangement, the so-called Greek, with the Latin cross, he proceeds to give in detail the internal arrangements of a Byzantine church, with its capitular or conventual buildings, the main character of which, as he notices, was so largely transferred to and continued in the architecture of the West. In connection with this part of the Christian world, Mr. Walcott notices in the first instance, as he did before with reference to the Eastern, the conversion of the pagan temples into Christian churches, of which, he says, the earliest instance was probably the Pantheon, consecrated to All Saints in 610;—next referring to what he denominates the Basilican style, and the development of the basilica into a church, with the internal arrangements generally of the latter so transformed.

It is at this point that we took leave of the information conveyed by Mr. Walcott, as it appeared in the shape of the paper alluded to at the commencement of this notice of his labours. Recurring to the latter as they appear in their more perfected form, we are introduced—upon the same plan of progress to that adopted in his previous treatment of the various matters spoken of—to some curious particulars in relation to round churches and baptisteries; and from thence to the consideration of Lombardic, and the later phases of Gothic architecture, as exhibited in Italy, Sicily, Palestine, Germany, France, and other continental countries, and England. It would be impossible, as must be apparent from the extensive range embraced, to follow Mr. Walcott through the whole course of his review;—for other than a few observations and extracts in connection with points of peculiar or general interest, or as showing the diversified and comprehensive nature of the information included, we must refer the reader to the work itself.

Speaking of the first of the subjects we have just alluded to—namely, Round Churches, Mr. Walcott says,

> "The round church was probably peculiar to towns either unimportant or of a limited population. The baptistery of Florence, built by the Lombardic queen Theodolina, was the old cathedral; and, until the eighth century, the Church of St. Lorenzo, of the time of Justinian, a square with four apses, was the cathedral of Milan. An octagonal building to the east of it was possibly a chancel. A baptistery stands on the south. The baptistery of Constantia, Rome, c. 440, that of St. Agnese, and the tomb of St. Helena, St. Stephano Rotundo, Bologna, of the fifth or sixth century, and the tomb of Theodoric, now St. Maria Rotunda, were circular. Again, we have also octagonal buildings, such as the Lateran baptistery, and that of Parenzo, St. Constance, St. Stephen le Rond, Rome, and, with cellular indentations, SS. Marcellinus and Peter, Rome; St. Tiburtius is a Greek cross; and mention is made by Eusebius of an octagonal church at Antioch, built by Constantine. The baptistery of Pisa was built c. 1152. The tomb, however, of Galla Placidia at Ravenna, built before 450, is cruciform. The circular form had been adopted for the mausolea of Augustus, Cecilia Metella, and Adrian, and the temples of Vesta and the Sun. Almost all the German churches of the time of Charlemagne, as at Aix-la-Chapelle, Nimeguen, and Magdeburg, were circular. In England, and frequently in Germany, as in Spain and Italy, a choir was added to the round church. At Bonn, an oblong nave, as in France, was built in conjunction with the circular building. In the eleventh or twelfth century circular churches began to disappear. In England and Germany the nave was of this form; but in France the choir, as at St. Benigne, Dijon, of the seventh or eighth century, and partially reconstructed in the beginning of the eleventh century; St. Martin's, Tours, of the fifteen century, and Charroux. At Perugia, Bergamo, and Bologna, of the tenth or eleventh century, the nave was round, and the choir oblong and apsidal. The round nave of the Templar's Church at Segovia, c. 1204, has a choir and aisles terminating in apses. Round churches are found in the island of Bornholm. At Wisby a two-storied church has an octagonal nave and rectilinear choir."

Of Baptisteries he remarks as follows:—

> "The public baths of the Romans, in some cases, became converted into baptisteries: the piscina was the ordinary cold bath of a Roman villa. After the conversion of Constantine, distinct buildings of an octagonal shape were built in front of churches, as at Rome, Nocera, Piacenza, Torcello, Novara, and Ravenna, a plan perpetuated to the thirteenth century by the Lombard architects; but almost universally, with this exception, were no longer built after the eleventh century, when parish churches were permitted to have a font. The western baptistery became, after a while, merged in the western apse in Germany. In Italy it served still as a baptistery or a tomb-house."

On the Lombardic and other later styles he says,

> "The basilica was a parallelogram, with an internal transept, an apsidal termination at one end, and a porch at the other extremity. The Byzantine church subordinated nave, choir, and transept, as the supports of a central dome; which was the development of the vault, as the vault was of the arch: the ground plan at first was a round or octagon, became a square, rendered cruciform by the four limbs rising above the angles round the cupola: three semicircular, latterly polygonal apses, formed the east end. The Lombardic, which lasted from the seventh to the thirteenth centuries, comprised both these types. It had a long nave, triforium, a central octagon, and cupola set on a square base, making an internal dome; an east end terminating in three apses; sometimes an octagon and an oblong were arranged to form a church. The eastern aspect of the sanctuary and the cupola are its Byzantine features: the Latin cross, the lengthened nave, the apsis and crypt, the latter becoming spacious and lofty, are Roman characteristics. Triforia, or galleries for women, are built along the aisles of the nave and transept; pillars are grouped; and the roof is of stone, vaulted; but the narthex disappears, to be resumed in the eleventh century as a porch. The baptistery and campanile are nearly invariable, but detached adjuncts. The earliest Lombardic church existing is said to be St. Michele at Padua, built 661. This is contradicted by Reunohr, who attributes it to the eleventh or twelfth century. Conventual buildings became prominent and numerous, such as the cloisters of Verona, St. John Lateran, Rome, and Subiaco, of the twelfth and thirteenth centuries. At Coblentz, in 836, and at Cologne, the Lombardic style established a home, reaching France in the beginning of the eleventh century, and England in the latter part of the reign of Edward the Confessor."

The divisions of the first-named he gives from Gally Knight, the first being

"1. From the incursion of the Lombards to the end of the eighth century: *e.g.*, St. Michael Pavia, which is cruciform, and, like St. Ambrose, Milan, has a clerestory, but no triforium; Brescia Cathedral, which is round, with a projecting chancel; St. Julia, octagonal; and St. Ambrose, Milan, 861, which retains its atrium. 3. The eleventh century: *e. g.*, Pisa Cathedral, 1063–1130. 2. The twelfth, and beginning of the thirteenth century: *e. g.*, baptisteries of Pisa and Parma, and the round tower of Pisa, 1147."

On Italian Gothic, including the Sicilian, he continues:

"The Duomo of Milan, and the Church of St. Giovanni at Naples, were built by German architects in the Gothic style, but there to remain, with a few others, as isolated specimens among the structures of the new school of Pisano. The development of Lombardic into Gothic architecture is marked by rapid changes. The crypt and Latin cross remain; but a spire rises over the central lantern, lateral towers flank the west front, the baptistery shrinks into the font, a lofty screen rises before the choir, which is lengthened out, and porches over the entrance doors. The characteristic 'bull's eye' window in the west front became the rose window of the Gothic style. There is no instance of a French chevet. The churches are either (1) basilicas, or (2) apsidal churches, where the aisles do not extend round the apse; and a series of apsidal chapels is sometimes added on the east of the transepts. Bologna, built c. 1390, is a three-aisled basilica, with an eastern central apse, and square-ended lateral chapels along the entire length. Bari, c. 1171, has a square east end, internally apsidal, with flanking towers, lateral sacristies, a central cupola, and projecting porches, a Lombardic feature. Novara, of the eleventh century, retains its atrium, connecting it with a baptistery. Pisa, 1063–1113, has double aisles to the choir and nave, an eastern apse, and an apse to each wing of the transept. Milan, begun 1386, comprises a nave and two transepts, all with double aisles; a choir with a trigonal apse, and north and south sacristies. The baptisteries of Pisa and Parma, of the twelfth century, and those of Verona, Pistoia, and Volterra, like the earlier examples of Ratisbon, Cremona, 800, Florence, 671, St. John Lateran, 440, and Ravenna, 390, are octagonal; that of Padua is a square in plan, and circular above. It is not improbable that the octagonal churches were so built in order to receive a dome. One of the earliest instances of the Pointed style is St. Andrea, Vercelli, built by an Englishman in the thirteenth century. It has a square east end, and two polygonal chapels attached to each transept. The west end is flanked with towers, and there is a central octagonal dome. At Sienna, begun 1243, we have the triple-gabled front, circular window, and three portals of the characteristic Italian type; a square east end, with the central alley having a niche-like apse in the wall, three aisles throughout the church, with eastern square chapels to the transept, and to the south wing a belfry attached, and a central dome. Florence, begun at the extreme close of the thirteenth century, is transverse triapsal, like the early churches of Cologne, and our modern St. Paul's, and has a central dome, begun 1420. Milan, commenced 1385, has a five-aisled nave, a shallow transept with aisles, and trigonal apses, and one trigonal eastern apse, with a circlet of columns, a compromise between the French chevet and the German apse. There is a central octagonal lantern. A western transept is found in conjunction with an octagonal tower in the centre of it, at St. Antonio, Piacenza, c. 1014; and two western towers, like a *quasi* transept, appear with a western cloister, at St. Ambrogio, Milan, rebuilt in the twelfth century. The cruciform cathedral of Pisa was built by Buschetto di Dulichio, a Greek. An apsidal eastern aisle occurs at St. Antonio, Padua; St. Stephano, Verona; in the Lateran, and Milan Cathedral; the former has radiating chapels. The entire east wall of the transept is often pierced with an arcade of five or eleven arches, opening into parallel chapels, the larger or central forming the east limb of the cross; there are eleven at St. Croce, Florence, 1290–1320; seven at St. Domenichino, Sienna; and five at St. Anastasia. Chapels along the side walls seldom form part of the original design.

Sicilian Gothic Style.

Monreale—which Messina resembles—has a three-aisled nave, a choir with chamber-like aisles, and three eastern apses, the central being the largest. The influence of Saracenic art is very perceptible in the use of domes, at St. Giovanni degli Eremiti. Cefalu, c. 1131, has aisles, a transept, and three eastern apses, but no central tower. The Cathedra of Syracuse, as in other instances, consists of the cella of an ancient temple, and interior galleries and aisles are formed out of exterior porticoes."

His observations on the Northern development of the Lombardic, and on the several peculiarities of the succeeding styles above mentioned, we give seriatim in his own words. They will be found in many points very interesting and suggestive. As respects the first we find as follows:—

"The formation of the western apse, the construction of an eastern aisle, the development of the choir, the formation of the ante-choir, and the double-gate at its entrance, with the altar of the Saviour, were probably innovations of the northern architects. The next great change was the erection of a central tower upon four pillars, like the Byzantine dome. Charlemagne constructed the central dome of his churches on eight pillars, introducing a still more important change—isolation, a passage on every side, a method of central junction by means of arches, and an advance to a loftier method of construction. Four central pillars, a development of this primary idea, are found at St. Martin d'Angers, built by the Empress Hermengarde, not long after Germigny, and in all English churches of the period; also at Hitterdaal, a timber building, in Norway, and at St. Savin, Aquitaine, begun 1023. At Germigny, the choir occupies this central space, and at Vignory, before the tenth century, there was a square of six pillars, inclosing the choir, with a processional path opening upon six chapels. In the Church of St. Savin, Aquitaine, begun 1023, we find four central piers, a transept with an eastern apsidal chapel in each wing, and five semicircular chapels ranged round the choir, which is an arrangement never found in the south. To the necessity for strengthening the central supports we may refer the construction of engaged shafts, as in the church of St. Miniato at Florence."

In Palestine the principal remains

"Are Byzantine, but there a few relics of Pointed architecture: the Hospital Chapel of St. John, not of later date than 1187, adjoining the Byzantine ruin of St. Mary de Latina; a similar chapel, Transitional Norman, at Sebustieh, with an octagonal apse; the Early English Cathedral of St. Andrew, at Acre, with a cloister along the west front as a defence against the sun; an hexagonal Templar's Church at Altlect, forming a hexagon, with three eastern chapels with pentagonal apses; the Church of St. George at Lydda, and the apsidal Church of Emmaus, erected towards the close of the Frank dominion, and the only Christian building which is still entire. The Church of the Holy Sepulchre at Jerusalem, as rebuilt by the Eastern emperors in the eleventh century on the site of Constantine's basilica, consisted of three western apses to the rotunda, and three eastern apses: three apsidal chapels on the north, and one apsidal chapel on the south, like transepts. It presented, before the fire in 1808, the rotunda with its three western apses; a cruciform building, built by the Latins, to the eastward, with three eastern apses, and a surrounding aisle to the presbytery; and transeptal chapels. The six churches of St. Stephano, at Bologna, were laid out in imitation of the grouped churches of the Holy Sepulchre."

With reference to German architecture it is stated:

"In Germany, at the end of the tenth or beginning of the eleventh century, a modified basilican form appears, at Gernrode, c. 960; Hildesheim, 1001; Limburgh, 1034; Mayence, Worms, and Spires. The basilican form is found at Ratisbon, Paulinzell, and Schwarzach. The type adopted was a double-apsidal cruciform ground plan, as in the east of France at Besançon, Verdun, at Trèves, St. Sebald, Nuremburg, St. Cross, Liège, and originally at Strasburg; west and east transepts, a long nave, a short choir, both of three aisles; small round octagonal towers were multiplied, flanking the apses, or attached to both the west and east fronts in churches not cruciform. Polygonal domes or octagonal lanterns were employed at the west end, and at the intersection of the nave and choir, and galleries were constructed under the eaves of the roof for the accommodation of women. The Rhenish type was three aisles ending in three apses; the earliest chevet, that of Magdeburg, c. 1254, is polygonal. At Hildesheim we find a short apsidal choir, with three apsidal chapels opening upon an aisle on three sides, but not communicating with the nave; a western transept flanked, like the main transept, with octagonal towers, and a west door wanting. There are chapels east of the main transept. St. Gereon, at Cologne, of the thirteenth century, has a circular nave, and is one of the last examples of a domical building. Cologne has a chevet with seven chapels, c. 1322, five aisles throughout the church, and a partially developed transept. Friburg has a western steeple, found also at Ulm; a low, ill-developed transept, and octagonal towers flanking the junction of the nave and choir, round which are twelve chapels. Strasburg was intended to have two western towers, and the whole east part is a basilica of the eleventh or twelfth century; the transept is ill-defined. Ratisbon, 1275 to the fifteenth century, has three east apses, and a 'subdued transept.' St. Stephen, Vienna has—as Prague, c. 1346, was designed to have—two transept towers. At Bamberg, 1220-57, there are two apses, west and east, flanked by towers. Naumberg is of similar design. Augsburg, 1366, has a chevet at one end, and an apse at the other. Marburg, c. 1283, is transverse triapsidal, with three round apses to the choir and transept. Xantan, thirteenth and fourteenth centuries, has two western towers, without an entrance on this side, with a polygonal apse, and four flanking chapels opening in the choir and aisles. At St. Severus, Erfurth, three spires rise in place of a transept over the apse. At Ireja Matriz, Vianna, c. 1483, there is a double transept. St. Cunibert's, Cologne, consecrated 836, was the first instance of the Lombardic style in the Rhenish provinces. Owing to their extreme regard for orientation, the apses are rarely surrounded with aisles or chapels; the churches are either (1) simply apsidal; or (2) like Byzantine churches, parallel apsidal, as at Laach, St. James, Ratisbon; St. Catherine's Lubeck; Marien Kirche, Mulnhausen, Weisenhausen, and Soest:

or (3) transverse or transeptal triapsidal. The early churches had circular east apses, as at the Apostles', Cologne; Marburg has three later apses, transverse triapsidal, of polygonal form. This arrangement is found also at St. Fidele, Como. Sometimes, but rarely, the choir is apsidal, and the aisles square-ended, as at St. Nicholas, Lemgo. There is sometimes an imitation of the chevet, as at Hildesheim, Magdeburg, and Marien Kirsche, Lubeck. St. Giles, Brunswick, has an apse and surrounding aisle, but no eastern chapels. In the north-east of Germany, as at Munster, there is no distinction between the nave and its aisles; that church presents a cruciform plan, two west towers, and west and main transepts, and an apsidal choir with apsidal chapels opening on a surrounding aisle. De Lassaulx regards the great Rhenish churches as a century later than the date ordinarily assigned.

German architecture resolves itself into three periods. The earliest Romanesque buildings date from 960 to 1000. The Abbey of Heisterbach, which is pure Romanesque, was not finished till c. 1230. Throughout the south of France there are remains of earlier Romanesque buildings than those in Germany. Aix was a copy from St. Vitale, Ravenna, and the latter from St. Sophia. The great consummation of the style at Boppart and Limburg was c. 1200; and c. 1230 the German taste was reimported into Italy at Assissi. There are a series of churches on the Rhine, erected in the twelfth century, formed on the plan of the Greek cross, and surmounted by a cupola, which was afterwards changed into a square tower. In the churches of Frose and Gernrode, in the Hartz district, built about 958, the commencement of the transept might be found. The vestibule of Lorsch is c. 794. (1.) The pure Romanesque pure churches have a semicircular domical apse, lower than the choir (as in several churches at Cologne, Mentz, Spires, Worms, Laach, and Eberbach); and frequently the aisles have similar terminations; some churches (as St. Mary Capitoline, the Apostles, and St. Martin), have apses to the ends of the transepts, instead of the usual triple eastern apse; and (at Johannisberg, St. Peters, Gelnhausen, and Laach) the east sides of the transept received semicircular apses. There is a western narthex at St. Gereon, St. Martin, St. Cuthbert, and the Apostles', Cologne. The towers are generally near the east end. There is an apsidal outer gallery round the choir at Laach, Eberbach, Worms, Spires, St. Gereon's, St. Martin's, and St. Mary Capitoline, Cologne. There are usually two pairs of towers and two cupolas or octagonal pyramids. St. Martin's and St. Castor's, at Cologne, are of this period. A portal cloister, as at Laach and St. Mary Capitoline, Cologne, is another distinctive feature. The sides of the towers terminate in pediments, and in these gables Ducange has ingeniously discovered the germ of spire-growth; but possibly the pyramids and obelisks of the East suggested the primary idea. In the (2) Transitional or Early German style the apse became polygonal, and of equal height to the choir, and the east chapels of the transept have seldom a simple semicircular form, but have sometimes an additional recess (as at Gelnhausen and Sinzig); or another form (as at Limburg), or wholly disappear with the transept (as at Andernach, Boppart, and Bamberg). At Mentz, Worms, St. Sebald's, Nuremburg, and at Bamberg, the eastern apse is round, and the west apse polygonal; at Bonn the ends of the transepts are polygonal, and the choir apse semicircular. The churches are of three aisles, and often have a polygonal (as at Bonn and Marburg) or semicircular end to the transept. Generally, where there are double apses, there are west and east transepts, as at Mentz, St. Cunibert's, the Apostles, St. Andrew's, St. Pantaleon's, Cologne; St. Paul's, Worms; and Nuremburg. Two pairs of towers on the east and west occur at Bamberg, Andernach, Bonn, Arnstein, and Limburg. There is a central octagonal tower at Limburg, Gelnhausen, Seligenstadt, Sinzig, Worms, Hermersheim, and Bonn. Sometimes there is a central spire between a pair of towers; sometimes two eastern towers (as at Gelnhausen and St. Cunibert's, Cologne); sometimes west towers as at Limburg, Bonn, Seligenstadt, Sinzig, Hermersheim, and Boppart. A similar group is often found like a transept at the west end, and sometimes a single west tower in the central compartment of this front. The gables of the towers become more acute, and the cornices lighter. Buttresses were used, and porches were added at the west end. At Augsburg there is a double choir. Chapter-houses are rare in Germany and France, and seldom circular. A baptistery is attached to Meissen. At Worms, about the beginning of the twelfth century, there is a west octagonal lantern flanked with round turrets, a central octagon, and east end flanked with round turrets. Spires, of the eleventh century, has an octagonal lantern at the intersection, and west square towers to the transepts. Mayence has a western apse composed of three trigonal apses, 1200–1239, an octagonal steeple and west turrets, and an east lantern and a round turret; the lateral chapels were added 1260–1332. At Laach, c. 1093–1156, we find the ancient parvis before the church with a west cloister, as at St. Ambrogio, Milan; a western apse, used as a tomb-house; a square west tower, with a transept, flanked by lofty circular towers; an eastern transept, a central octagonal lantern, flanked by two square turrets; an apsidal choir, and transepts with eastern apses. Lateral porches supplied the place of a western door. The Apostles' Church, Cologne, has a tall west tower and transept, a central octagon, and two flanking turrets. St. Castor, Coblentz, Andernach, and Arnstein, have two groups of towers, but no central lantern. The third period is the complete or Decorated German, which occurs at Altenberg, Cologne, Freiburg—which has twelve chapels to the choir,—and Ratisbon. There are two west towers at Zerbst Nicolaik, Meissen, Mulnhausen, Mildenfurt, Naumberg, and Memleben. Trèves has a double east and west apse. Gelnhausen has an eastern trigonal apse, a transept with eastern apsidal chapels, a square west tower, a central octagonal lantern, and two towers flanking the apse. St. Katherine's, Oppenheim, has a trigonal apse, two west towers, and central octagonal lantern. Limburg has two west towers, a central lantern, two towers flanking each transept, and a round apse. St. Elizabeth, Marburg, has pentagonal apses to the choir and transept, and two west towers. There are two west towers at Munich, Augsburg, Cologne, Basle, Thurme, Marburg, St. Laurence, Nuremburg, and one at Frankfort. Ulm has no transepts, but comprises a nave with double-aisles, a choir with side chapels, and a large porch under the west tower. Stuttgardt, 1419–1531, has a west tower, dwarf transept, a choir with a trigonal apse, and a nave with aisles and chapels. Augsburg has a double apse, that to the west trigonal, and a nave with double aisles. Ratisbon has two west towers, a nave with aisles, an ill-defined transept, and a parallel triapsal choir with aisle, each with a trigonal apse: to the east of each aisle is a chapel. St. Sebaldus, Nuremburg, has west towers, a double apse (each pentagonal) and transept. M. Dahl has published an account of similar structures of the eleventh and twelfth centuries. The Cathedral of Lubeck has a three-aisled nave with lateral recesses, an unimportant transept, and a chevet, with seven polygonal chapels and cloister. St. Mary's is three-aisled, has two western towers with no entrance on this side, a low transept, consisting of chapels; and a chevet with five polygonal chapels. Dantzic is cruciform, with a west tower. At Zurich, the choir, of the eleventh or twelfth century, is square, while the aisles terminate in apses, and two west towers wêre contemplated. A thirteenth century church at Kaschau, Hungary, attributed to Villars de Honecourt, has a French arrangement of eastern chapels. In this country however the common type is a triapsidal basilica, with a narthex and western towers. Buda, of the same period, has three eastern apses and two west towers."

Speaking of Swedish and Norwegian architecture, Mr. Walcott informs us that between Stockholm and Upsala, c. 1000, several churches strongly resembled Anglo-Saxon buildings; and that the Norwegians, when about to restore the Cathedral of Drontheim, sent artists to make sketches of Kirkwall, which had been previously built by Norwegian workmen. This connection and interchange between England and the above countries, as respects architectural production, is recorded in other cases. It was by missionaries from England, during the primacy of Elfric (994–1005), that Christianity was introduced to the pagan subjects of Olaf Tryggvason (or Olaf the son of Trygg), king of Norway, the grandson of Hacon surnamed Adelstanfostri, or the foster-son of Athelstan king of England (925–940); and the head of the mission, Sigefried, archdeacon of York, died bishop of Wexio, in East Gothland. We have alluded to this relation between England and Norway in ecclesiastical matters in a former number, when reviewing a work on the Domkirke of Throndheim, published by the Norwegian government (see this Journal for May 1860). To the instances there mentioned as showing the reference to England and Englishmen, Mr. Walcott adds another: the see of Strengnäs, in Sweden, was, he says, established by Oskild, an Englishman. He also says, quoting from the Proceedings of the Royal Institute of British Architects, 1844-5, p. 86, that "some of the Swedish cathedrals were built by workmen from St. Germain des Près."

Belgic Gothic architecture Mr. Walcott divides in brief into—1. Primary Pointed and Transitional, tenth to thirteenth century: ground plan a Latin cross; west door isolated, and in Transitional cases lateral entrances to nave and choir, removed under a single porch, deeply recessed, at the end of the transept, in the thirteenth century. 2. Secondary Pointed or Rayonnant, fourteenth to the latter part of fifteenth century, marked by large windows above entrances, side chapels to naves; lady-chapels rare. 3. Third Pointed or Flamboyant, latter part of fifteenth to latter part of sixteenth century.

Spanish architecture presents two styles—the southern, or indigenous, and the northern, borrowed from France; principally presenting "either the French chevet with a circlet of chapels, or an apsidal aisle surrounding the altar, and opening on chapels, with an eastern chapel, which if the east end is square is the lady-chapel,—if circular or octagonal, a tomb-house."

For the main divisions of French mediæval architecture Mr. Walcott adopts those of M. Caumont, as follows:—1, Roman; 2, Ogival Primitif (thirteenth century); 3, Ogival Secondaire (fourteenth century); 4, Ogival Tertiare, the latter being separated into two epochs, respectively 1400–1482, and 1480–1550. To example in illustration of the various phases and peculiarities of these several divisions, as well as those of the other parts of the Continent mentioned, with many other minor points in connection therewith, there is abundance of very interesting reference. The originating causes of several of such peculiarities are also very satisfactorily adverted to.

From the architecture of France Mr. Walcott proceeds to that of England, previously noticing that of Ireland and Scotland, both early and later. These sections of his work are succinct and valuable. In reference to the former, he remarks of the Celtic churches: they are "small aisleless, rectangular buildings, without an apse, usually in groups of seven, like the churches in Asia Minor and on Mount Athos. In the fifth century," he continues, "they are of a type anterior to the Roman basilica, and many were built of timber, with some affinity to Scandinavian architecture. From the ninth to the twelfth century they were Romanesque, with a basilican arrangement; the throne, or a bench-table, being at the east end, and the altar detached." Some of the round towers, he observes, somewhat resemble the conical Nuraghies of Sardinia. The original plan of a simple oblong, or of a nave and chancel, was preserved to the latest period. The cloister of Kilconnel, he adds, resembles cloisters in Spain and Sicily.

In Scottish architecture is embraced—1. Churches of wicker-work, which in the fifth century gave way to stone churches, like that built by French workmen at Whitherne for St. Ninian, and another constructed in the eighth century by monks from Jarrow. 2. Scoto-Irish, from the middle of the sixth to the middle of the eleventh century. 3. Romanesque Anglo-Scottish, 1124–1165. 4. Lancet, 1165–1286. 5. Decorated, 1286–1370. 6. Flamboyant, 1371–1567. The saddle-back tower and polygonal apse are referred to as continental features; and Roslyn, it is remarked, was built by architects from the north of Spain.

In the section on English architecture are noticed various kinds and forms of churches, from the primitive erections of wattle and stud-work, down to the introduction of the stone edifices of a later period, and from thence to the full development of the latter. These notices are full, and comprise nearly all the historical evidence we now possess on the subject. They are moreover very conveniently arranged under separate and particular heads, corresponding with, and having relation to, the particular features and distinguishing arrangements both of the secular and monastic clergy, in their churches and conventual erections. After alluding generally to Anglo-Saxon and the later styles of English architecture, and giving very nearly its generally-received divisions,—to symbolism, and orientation, &c., we have reference to the principal varieties observable in the ground plans of churches, and of their crypts, &c., followed by remarks on the Benedictine, Cistercian, and Augustine churches and convents, with those of the Præmonstratensians, Franciscans, and other religious orders. These are highly interesting and instructive, both historically and otherwise, including as they do almost every peculiarity of feature and disposition in our ancient ecclesiastical buildings.

We cannot follow Mr. Walcott in detail through all these matters, but we may observe that his notices refer, amongst almost every other component and accessory feature, to west fronts, porches, galleries, doors, towers, transepts, choirs, altars, apses, stalls, pulpits, thrones, sedilia, screens, sacristies, baptisteries, lady-chapels, &c.

As respects conventual arrangements, he refers, upon the same plan of separate consideration, to the ground-plan, first alluding to the convents of the East and Greece, and afterwards to those of the Continent, and England. Of the general arrangement of a monastery he says as follows:—

> "Each monastery included (1) a cloister-court: (2) an inner court, with the infirmary, guest-house, kitchen, servants'-hall, library, &c.: (3) great or common court, with a double gateway, the larger arch being designed for carts; granaries, stables, store-rooms, servants' rooms, tribunal, prison, the abbot's lodge, and grange-barn; a remarkable instance occurs in the Præmonstratensian Abbey of Ardaines, near Caen: (4) the court of the church or close, open to the public: and (5) mills, gardens, orchards, &c."

From the general arrangements—adverting to that of Canterbury as being the earliest plan of an English monastery extant—he proceeds to particular parts, such as the cloisters and capitular closes, chapter-houses, the slype (supplied, he says, in the Cistercian houses by the sacristy), the dormitory, refectory, lavatory, cellarage, kitchen, treasury, library, scriptorium, abbot's parlour and lodge, infirmary, guest-house, prison, gate-house, school, almonry, and charnel-house, &c.; illustration or confirmation of the statements being in each case that of existing or recorded authority.

Having thus directed the reader to the comprehensive nature and usefulness of Mr. Walcott's work, we would call the attention of that gentleman to one or two little discrepancies, which it is hardly possible, perhaps, but should occur in the extract and arrangement of the many references and illustrations which the work contains. In some of the former a little confusion is created by the omission of the mention of the particular edition or series, as the case may be, of the work quoted from. In the latter there are also one or two minor matters in connection with the plans; and we allude to both the rather that they are easy of correction in future editions. In the plan of Canterbury Cathedral there is an omission of the steps which lead from the level of the nave to the north aisle of the choir,—which interferes with the idea and indication of an agreeing level with the opposite or south aisle of the choir. In the plan of Castle Acre Priory there is also some variation from the description of it. It is stated in page 74, that "a peculiarity of Clugniac churches in England is the position of the sacristy, which at Thetford and Castle Acre is attached to the north wall of the transept." It is omitted to be so indicated on the plan. There is likewise a difference between the latter and the reference to some of its features which occurs at page 65, which states that the transepts have eastern apsidal chapels," while on one of them only, the north, it is so shown. As respects the plan of Eastby Abbey, given at page 76, there appears also to be some error in the representation. Speaking of this ruin in another work by the same author, entitled 'The Minster and Abbey Ruins of England,' it is said, "The north aisle of the choir—itself of preposterous length—was longer than the south;" and again, that "the cloister court had only two alleys," and that "the abbot's lodgings were on the cold north side of the nave." On the plan the choir is shown without aisles, the cloister with four walks or alleys, and the abbot's lodgings on the north side of the transept, his hall abutting immediately thereon, his chapel running in continuation northward, and his lodge proper extending eastward therefrom, or parallel to the choir. In the plate of Westminster Abbey, the south transept, letter D in the reference, is denominated the E. or east transept. This latter is however a self-evident typographical error, though it would be better perhaps altered, or referred to in the errata.

Tables for Setting Out Curves on Railways and other Public Works. By J. S. Olver, Civil Engineer.—London: Weale.

These tables are given in one sheet, mounted on cloth and folded as a map, so that it may be spread out for convenient reference in the field. They are very comprehensive, being calculated for radii of from 1 to 800 chains, and for chords up to 40 chains. They seem to have been computed and arranged with great care and diligence: we cannot of course vouch for the accuracy of all the figures, but no error has caught our notice on an examination chiefly directed to ascertain the correctness rather of the principle than the detail of the calculations.

One portion of the table gives the off-sets at successive distances along the chord for setting out the arc required. We think this will be found extremely useful by those who have to range curves for engineering and other purposes in cases where the theodolite is not used: as calculations of off-sets on the ground are often tedious and liable to error. Of course, before using these off-sets, both extremities of the arc must be supposed to be ascertained.

The other part of the table furnishes the angle for any given chord. The angle given is (as appears from inspecting the tables) not that which is contained between the radii drawn from the centre of the circle to its chord, but the supplement of this angle. This is indeed equally available for theodolite ranging, if it is ever desired to range with the theodolite at the centre of the circle. Of course with large radii this would be out of the question.

It would, however, have been more serviceable to have given, instead, the angle contained between the chord and the tangent, (or what is the same thing, the angle at the *circumference* subtended by the chord.) For the ranging of railway curves, the theodolite is set in the curve and the angles read from the tangent, and it is usual to chain round the arc rather than along the chord, although for preliminary ranging long chords may be taken in the first instance. This, however, should always be done with an eye to ultimately carrying the chain measurement round the curve, so that it is more useful to know the angle (say) for an *arc* of 5 chains, than that for a *chord* of 5 chains. A table giving the correct chords for arcs of so many chains would be of very great assistance in the ranging of railway curves.

We know no better rule for theodolite ranging than the following:—

$$\text{Minutes per chain} = \frac{1719}{\text{radius in chains}}$$

Thus, with a radius of 40 chains, the chord of an arc of 1 chain makes with the tangent an angle equal to $\frac{1719}{40}$ minutes$=42'{\cdot}97$; the chord of twice this arc makes twice the angle, or 1° 25′·94, and so on. The most simple practical work on this subject we remember to have seen is a pamphlet by Mr. Robert Brodie, published many years ago. We think it does not give any tables.

This portion of Mr. Olver's tables would, however, be helpful in ranging, provided the halves of the supplements (or the complements of the halves) of the tabulated angles were taken,—a process easily performed in the field. We think many would be glad of the tables for the sake of the off-sets alone: certainly these are what would be found most generally useful.

Treatise on Mills and Mill Work,—Part I. By William Fairbairn, Esq., C.E., &c.—London: Longman. 1861.

This is the first portion of a work which the author states he has had in contemplation for many years. The present volume begins with the first principles of mechanism, and then proceeds to discuss the various constructions of prime movers. The author expresses a hope of shortly completing the work by a treatise on the new system of transmissive machinery, and on the arrangements necessary for imparting motion to the various descriptions of mills.

A short introductory chapter, under the head "Early History of Mills," gives some classical, antiquarian, and other gleanings of considerable interest. It might be wished that the author, having taken up this part of the subject, had treated it more at large, as it would admit of being much amplified; although our knowledge of the mechanical appliances of early ages must be acknowledged to be but fragmentary at the best. It is conjectured (and with probability) that

> "The earliest introduction of machinery was in the processes for the preparation of food, as we read of the Egyptians and Babylonians, and other nations in Europe and Asia, having mills for grinding corn at the earliest periods at which there are records of their history. Hesiod and Pliny both describe the most primitive method of the preparation of corn, a method still further illustrated among the pictorial remains of the Egyptians—viz., pounding it in a mortar."

To this we may add that the Proverbs of Solomon (which bear a date certainly as early as Hesiod) contain such an incidental allusion to the process of braying wheat in a mortar as proves it to have been then well known in Palestine. But of the corn mill itself we have yet more ancient record. In the Law of Moses, at a period about six centuries before Hesiod, and when the progenitors of the poet may possibly have satisfied their hunger with beech-nuts and acorns (according to traditional tastes), we find distinct reference to the nether and upper millstones, and mention made of the mill as in common household use. Allusions equally definite and familiar occur in a book of the Old Testament to which a yet higher antiquity has by some been assigned.

Mr. Fairbairn passes by a somewhat rapid transition from the archæology of mills to the manufacture of textile fabrics, and thence to the latest inventions in iron manufactures.

> "We are at the present time in a state of transition in the manufacture of iron and steel, which is making rapid strides towards improvement. The inventive talent of the country has been directed to this object, and the production of homogeneous plates, having the elasticity and tenacity of steel, together with the improvements of Mr. Bessemer, Mr. Clay, and others, are likely to produce a complete revolution by a greatly increased economy in the production of iron. Mr. Bessemer is now proposing to roll plates in the form of a continuous web from liquid metal, run direct from the furnace to the rolls. We cannot vouch for the success of this enterprise, but we are most anxious to see its results realised; and there cannot exist a doubt, from the number of able chemists and practical men at work, that the iron trade of this country is calculated to undergo a great change, and perhaps with as much benefit as was accomplished by Mr. Cort on the introduction of the puddling and rolling processes.
>
> . . . . Although much change has not been effected in the machinery of the iron manufacturer, considerable improvements have nevertheless been made in the smelting of the ores, and since the introduction of the hot-blast by Mr. Neilson the production of the furnaces has been more than doubled. Looking forward, therefore, to the improvements and changes now in progress, we may reasonably conclude that a new era is not only imminent, but has in great part been accomplished. The same progress, and even greater improvements, [are] observable in the conversion of iron into steel, and probably the time is not far distant when we shall be enabled to produce from the same furnace iron in either a cast or malleable state, or steel, as may best suit the requirements of the manufacturer. It is quite evident that our increasing knowledge of chemistry in iron manufactures leads to these results, and by a still closer adherence to chemistry, whereby impurities, such as phosphorus, sulphur, &c. are removed, the process just alluded to will be fully and satisfactorily realised."

The second section of the volume is contributed by Mr. Tate. It forms a very useful treatise on the elementary principles of mechanism, which are classed under the heads of link-work, wrapping connectors, wheel-work producing motion by rolling contact, and appliances for communicating motion by sliding contact, including of course the various modifications of the screw. The capabilities of link-work in converting equable into rapidly retarded or intermitted motion are well exemplified, one instance being Watt's simple and ingenious contrivance for opening the valves of the steam engine. Of course the beautiful arrangement of the "paralled motion" comes in for its share of notice; it is satisfactorily handled, with the exception of a mischievous error in printing, which spoils the sense. We read:—

> "The ratio of QE to EG is generally expressed by the following equality:—
>
> $$\frac{\text{QE}}{\text{GE}} = \frac{\text{R}}{r} \times \left\{ \frac{r \sin \frac{a}{2}}{\text{R} \sin \frac{\text{A}}{2}} \right\}."$$

It should be "$\frac{\text{R}}{r} \times \left\{ \frac{r \sin \frac{a}{2}}{\text{R} \sin \frac{\text{A}}{2}} \right\}^{2}$".

The very elegant problem of the mutual relation of form between curved surfaces having rolling contact is touched upon, and the instance of two equal ellipses rotating about their foci is given, and also that of two equal logarithmic spirals. The special investigation of the form of the teeth of wheels seems to be reserved for a future occasion. The question of the action of cams of various curved outlines also receives attention, and the employment of the spiral of Archimedes as the line of a cam groove is instanced as converting a uniform rotatory into a uniform reciprocating rectilinear motion. The diagrams are generally clear, although in a few instances the reference letters are vexatiously omitted (a great discouragement to beginners), and one figure (25) is lamentably out of drawing.

In giving the rule for the pitch of the screw there is an error:—

> "If t = BF, the distance between the threads of the screw, r = the radius of the cylinder, θ = angle BAF; then
>
> $$t = \frac{2\pi r}{\tan \theta}."$$

A reference to the diagram shows that the second side of the above equation should be "$2\pi r \times \tan \angle \text{BAF}$;" so that θ is evidently not BAF, but its complement BFA, or the angle which the thread of the screw makes with the sides of the cylinder.

The third section treats of prime movers, of which water power first comes under consideration. Mr. Fairbairn gives an instructive chapter on the accumulation of water in reservoirs.

> "It is necessary in constructing reservoirs to obtain some measure of the quantity of water which may be expected to accumulate annually, in order to provide sufficient storage. For this purpose it is most important to determine the area of land draining into the valley chosen for the formation of the reservoir, and the average annual rainfall of the district, with, if possible, the probable loss or waste arising from the re-evaporation and absorption by vegetation, &c.
>
> To ascertain the drainage area it is sufficient to determine the *summit level* or *watershed*, *i.e.*, the ridge surrounding the valley which marks the line at which the streams flow in opposite directions into contiguous valleys. This may be determined by a special survey, with a careful

> examination of an accurate chart like the Ordnance map, on which the contour of the country, brooks, &c. are plainly marked. The whole of the basin included within the watershed is termed the catchment basin. In the case of the Bann reservoirs it amounts to 3300 statute acres in extent; in that of the Greenock reservoirs to 5000 acres; at the Manchester waterworks to 19,000 acres."

After mentioning that an immense number of experiments have been made of late years on the rainfall in different parts of Europe, our author proceeds to give a table of the mean rainfall at London and Manchester. For London the average extends over thirty-four years, and Mr. J. H. Belville is cited as the authority for the data. The Manchester observations are stated to comprise a period of sixty-four years: for these Dr. Dalton and the Manchester Memoirs are referred to. It would be desirable to know how far these periods are synchronous, and what the average figures would be for the same term of years in each case. The results show a mean annual rainfall of 24·78 inches at London and 35·56 inches at Manchester. In the London table, March shows as the dryest month, the rainfall averaging 1·61 (or barely more than 0·05 inches per day); February comes next (allowing for the shortness of the month); and October ranks as the wettest, having a monthly rainfall of 2·67 inches. These conclusions seem hardly what would be generally anticipated; and the variation of the average rainfall from one month to another appears smaller than might have been surmised.

In the Manchester table this variation is more considerable. October is here too the wettest month, and figures at 3·84; *July* nearly rivalling it, however, with 3·72 inches average monthly rainfall; while April claims the place of the dryest month, having an average of 2·02. The greatest fall in London during any single month in the period of thirty-four years was 6·65, and occurred in July. The greatest rainfall for one month in Manchester also occurred in July, and amounted to 11·48 inches. The least rainfall for any one month is given in the London table as 0·04 in February,—April, August, and December following in order of casual dryness. In the corresponding column of the Manchester table, the mininum is in December, and amounts to 0·07,—May giving a small fraction more, or 0·09 inch. These differences sufficiently indicate the operation of local influences, affecting not merely the total quantity of rain during the year, but also the manner of its distribution in point of time.

Mr. Fairbairn observes that the London and Manchester tables

> "Would give a mean of 30 inches, but it must be borne in mind that in the lake districts, and all along the west coast, there is an annual fall of rain greatly exceeding that amount, and in some places in the higher districts in Cumberland the returns have been as high as 180 to 200 inches; from this it will be seen that 36 inches is a fair average for the whole surface of Great Britain."

We do not suppose our author would jump at a conclusion, and therefore infer that he has either computed the average he gives from a comprehensive examination of observations in various districts throughout the island, or adopted it from a reliable authority. Without some such supposition the sentence we have quoted would leave a painful impression of loose and inconclusive reasoning.

> "It is however important in the construction of reservoirs to have observations of the rainfall in the district in which they are to be placed. Local causes greatly influence the quantity of rain: thus the average fall in Essex is about 20 inches; whilst at Keswick in Cumberland it is as much as 67·5 inches, and at Seathwaite in the same county it averages the enormous quantity of 141·5 inches."

After describing the ordinary rain guage and the manner of using it, Mr. Fairbairn proceeds :—

> "By placing two or three of these rain-gauges at different elevations around the site of a proposed reservoir, and examining them at convenient intervals of a week or a month, it is easy to estimate the exact quantity of rain which falls upon the catchment basin in the course of one year; which, with certain deductions, is the quantity to be provided for in the reservoir. The precaution of placing the guages within 5 inches or a foot of the ground is important, as, in accordance with an ill-understood law, the quantity of rain rapidly decreases even at slight elevations from the ground, and it is also important to place the guage where no artificial currents of air are created, as by the sloping side of the roof of a house. This subject was fully investigated several years ago by Mr. J. F. Bateman and a committee of the Manchester Philosophical Society. Observations had been made on and near the lines of the Ashton and Peak Forest Canals, about the accuracy of which, from their disagreement, doubts had arisen. The guages in these observations were placed on the ridging of the roofs of the houses of the various lock-keepers, under the impression that, from the exposure of the position, all the rain which fell must there be caught. New guages were placed in the same localities, but at the surface of the ground, and the results of these experiments were as follows:—
>
> | Locality. | Guage on roofs. | Guage on ground. | Excess per cent. on ground. |
> |---|---|---|---|
> | | Inches. | Inches. | Inches. |
> | Near Middleton ... ... | 18·14 | 28·8 | 58·76 |
> | Near Rochdale ... ... | 20·50 | 30·3 | 47·8 |
> | Whiteholm Reservoir ... | 22·64 | 35·1 | 55·0 |
> | Blackstone Edge ... ... | 23·45 | 34·2 | 45·84 |
> | Blackhouse ... ... | 24·89 | 35·9 | 44·23 |
> | Sowerby Bridge ... ... | 16·77 | 23·8 | 41·92 |
>
> This enormous difference, amounting to 50 per cent. on the average, fully proves the unfitness of roofs for registering the rainfall. The upward currents of wind created by the sloping roof appear to have carried the raindrops over the edge of the guage.
>
> Dr. Heberden found the annual fall of rain at the top of Westminster Abbey to be 12·099 inches. On the top of a house close by, of much inferior altitude, 18·139 inches; on the ground, 22·608 inches.
>
> Mr. Phillips, at York, found the total fall for three years, at an altitude of 213 feet, to be 38·972 inches; at 44 feet, 52·169 inches; and on the ground, 65·430 inches.
>
> Notwithstanding the explanation of these facts which have been offered, Sir J. F. W. Herschel has within the last year asserted that the cause is yet to seek. The raindrops certainly appear to increase in size in the moist lower strata of the atmosphere.
>
> Mr. Phillips's explanation has been accepted by some meteorologists, that this augmentation is caused by the deposition of moisture on the surface of the drop, in consequence of its temperature being lower than that of the moist strata of air through which it passes. But this does not appear to be consistent with the fact, that in the condensation of vapour a large amount of latent heat would be liberated. Mr. Baxendale, who pointed this out, estimates from Prof. Phillips's observations that, in the condensation of the amount of water which corresponds to the augmentation of the raindrop in a fall of 213 feet, sufficient heat would be liberated to raise the temperature of the drop to 434° Fahr."

This seems conclusive against the idea of the increase of the raindrop through the agency of condensation, properly so called. It however still remains open to inquiry whether the drop may not in some way gather a portion of the moisture of the air through which it falls. To solve such a question satisfactorily it would be needful to know the relative proportions in which true vapour and watery particles held in solution respectively exist in the atmospheric moisture. In the deposition of dew we find that water really seems to exude from the air under certain favourable circumstances, without the sensible liberation of latent heat. It is perhaps not unreasonable to imagine a raindrop to accumulate watery particles in its fall, much in the same way that a large bead of quicksilver picks up the smaller beads or spray with which it comes in contact.

But as yet all this is mere speculation. We do not know that it is absolutely proved that the increased rainfall measured by guages on the ground, compared with that measured by guages on the tops of buildings is due, or mainly due, to the swelling of the raindrops as they descend. It should be remembered that a guage is likely to catch less than a fair share of any driving rain; so that the greater stillness of the air near the level of the ground and the steadier fall—not to mention the surface spray that a heavy shower frequently occasions—may have some bearing on the question.

After adducing data to show that mountainous districts in this country, to an elevation of 2000 feet, receive a larger proportion of rain than the lowlands, Mr. Fairbairn proceeds to consider the loss from evaporation and other causes before the water ultimately reaches the reservoir. This loss is in each case to be arrived at by guaging the mean discharge of the various brooks and streams, so as to find by what amount the quantity of water they deliver falls short of the total rainfall on the catchment basin. The next question is that of the capacity of the intended reservoir. On this point our author cites the following remarks from the Report of the British Association on Water Supply (by Mr. Bateman):—

> "The storage requisite for equalising the supply of water between dry and wet years should be provided with a due reference to the continuance of drought, and the quantity of water which will flow off the ground: in extreme wet seasons no water should be allowed to run to waste. Experience has shown that in the regions of comparatively moderate rain in this country, the storage to effect this object should vary from 20,000 or 30,000 to 50,000 or 60,000 cubic feet for each acre of collecting ground, the smaller quantity being about sufficient for an available rainfall of perhaps 18 in., and the larger for one of about 36 to 40 in."

We have taken leave to correct two manifest misprints in the above tables. It will be seen that in every case where the head is considerable, and the height of the rectangular outlet 3 or more inches, the actual discharge per second is (with small variations) 60 per cent of the theoretical discharge.

" *Discharge with incomplete contraction.*—It is very frequently the case in practice that one of the sides of a thin-lipped orifice is prolonged, so that the vein of fluid no longer contracts upon all sides. In this case the coefficients in Table II. and III. give too low a result. M. Morin gives the following rule for discharge with incomplete contraction:—Multiply the coefficient of discharge for complete contraction found as above by

1·035 when the vein contracts on three sides only
1·072 ,, ,, ,, two sides ,,
1·125 ,, ,, ,, one side ,,

in order to obtain the true coefficient by which the theoretical discharge must be multiplied to give the actual discharge. Hence, for an approximate calculation, we may multiply the theoretical discharge by 0·62 when the orifice is prolonged upon one side; by 0·64 when it is prolonged on two sides; and by 0·68 when its prolonged on three sides. When all four sides are prolonged, the thick-lipped orifice is formed, of which the coefficient of efflux is 0·8."

Very interesting researches on the discharge from rectangular notches, wasteboards, and weirs, on the friction of water in pipes, and on the estimate of water-power, concludes the chapter, which contains some very useful tables. We propose giving consideration to the remaining portions of the work on a future occasion.

A Complete Treatise on Cast and Wrought Iron Bridge Construction. By William Humber, A. Inst. C. E., M. Inst. M. E. Folio, 2 vols. (text and plates).—London: Spon.

This appears to be a very valuable contribution to the standard literature of civil engineering. The second volume contains eighty lithograph plates of large size, illustrative of Westminster New Bridge, Charing Cross, Victoria (Pimlico), Saltash, Londonderry, the Jumna, and more than a dozen other bridges. In addition to elevations, plans, and sections, large scale details are given, which very much enhance the instructive worth of these illustrations. An excellent photograph of the Saltash (Royal Albert) Bridge, as it appeared when one bay was complete and the truss for the other bay nearly ready for hoisting, forms the frontispiece to the first volume, which contains the text. This is divided into three parts, theoretical, practical, and descriptive.

The theoretical part appears to go very thoroughly into the elastic strength of materials, transverse strain, moment of inertia, shearing strain, plate and trussed girders of various constructions, continuous girders, arches, and suspension chains; and contains copious tables and diagrams. The practical part treats of design, manufacture, and construction, not omitting iron piers and foundations. The third part furnishes descriptions of actual bridges, and, taken in conjunction with the volume of plates, forms the most interesting and instructive section of the work.

We propose to take an early occasion of giving a more detailed examination to the text than we are now able to bestow. We will here simply say, that no engineer would willingly be without so valuable a fund of information; the bridges illustrated being (many of them) among the most original and successful works of the day.

Collieries and Colliers: a Handbook of the Law and Leading Cases relating thereto. By John Coke Fowler, Esq., of the Inner Temple.—London: Longmans and Co.

This handbook of the law on matters relating to mining is intended principally for convenient reference for non-professional persons engaged in collieries. It takes a very comprehensive view of the law relating to the subject, comprising in its survey the nature of property in coal, leases of mineral property, covenants to work coal, rights of way, rights connected with the flow of water, the contract of hiring between masters and colliers, the rating of collieries, injuries caused by mining, accidents in collieries, manslaughter, combinations among workmen, the universal law relating to collieries, together with other subjects of special interest to those engaged in such works. It is not a dry law book, but is an explanation and commentary such as may be perused with advantage by other readers than those to whom it is especially addressed; several of the matters treated of, such as the right of way, and the rights connected with the flow of water, having a general interest.

NEW THEORY OF THE FIGURE OF THE EARTH.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

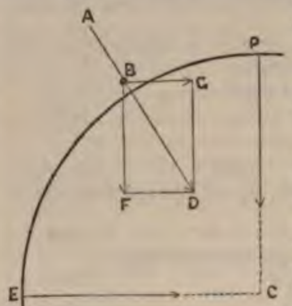
Sir,—Mr. Bakewell, in his paper with the above heading, seems to have been misled into drawing an erroneous conclusion from a true principle, by a temporary confounding of the meanings of the terms "towards which" and "where."

1. He states in the first place that "a body perfectly free will move in the direction *towards which* it is most strongly attracted or impelled." (The italics are mine.)

2. From this he proceeds to infer that "water on the surface of a solid sphere will flow towards the part *where* it is most strongly attracted."

In drawing this inference, Mr. Bakewell reasons as if "*where*" and "*towards which*" were identical in meaning; but throughout the rest of his paper he evidently uses "*where*" in its proper sense of "*at which*,"—that is, as denoting, not the place towards which the attracted body is drawn, but the position of the attracted body itself; and when this is understood, the second of the above propositions not only fails to follow from the first, but is directly opposed to it. Water, under the circumstances described, would flow not *towards*, but *from*, the place of strongest gravitation on the surface of the sphere, exactly as it would do if its density were increased at that place, gravitation remaining uniform; or if a pressure were brought to bear on it at the same place.

To illustrate further the difference between attraction *at* a place, and attraction *towards* a place, it may be remarked that attraction *at* the poles acts *towards* the plane of the equator, and attraction *at* the equator acts *towards* the axis; so that if the attraction exerted by the sphere on the fluid covering it be from any cause weakened at the equator, the attraction exerted on the particles *at* and *near* the poles, urging them *towards* the plane of the equator, becomes the stronger; and the particles of the fluid tend to sink and spread at the poles, and to collect and swell at the equator.



In the case of a plumb-line AB the attraction BD exerted on the bob B may be resolved into two components; BF parallel to the axis PC of the sphere, and to the direction of gravity *at* the pole P, and acting *towards* the equatorial plane; and BG perpendicular to the axis of the sphere, parallel to the direction of gravity *at* the equator E, and acting *towards* the axis. If by any cause the component BG is weakened or partially counteracted, the plumb-line will assume a new position of equilibrium, so that the bob will be further from the axis and nearer to the equator.—I am, &c.,

R.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—I have read with some surprise a paper in your number for this month, by Mr. Bakewell, propounding a new theory of the figure of the earth. I am aware that you cannot be considered answerable for the opinions advanced in articles to which the names of the writers are attached. I am also aware that a monthly journal can hardly be expected to lend much space to letters of controversy. But the paper referred to is altogether of a very unusual character, and appears really to challenge a comment from some of your readers, appealing as it does to their verdict against the ruling of the scientific world in general.

Mr. Bakewell gives, in the words of some mathematician from whom he differs, a lucid explanation of the real operation of the Earth's centrifugal force, that would seem to leave nothing to be desired. This force, which is always parallel to the plane of the equator, is resolvable into two: one, in the direction of the plumb-line (or earth's radius), tending to abate the downward pressure of gravity; the other, horizontal, and tending to drive matter on the Earth's surface towards the equator, in the direction of the meridian line. The inference from this resolution of forces is, that the attraction, or impulsion, towards the equator varies as sine (lat.) × cosine (lat.), while the abatement of the vertical pressure varies as the square of the cosine of the latitude. At the pole the vertical pressure of gravity suffers no abatement;

at the equator the abatement reaches its maximum; and in latitude 45° the impulsion towards the equator is at its greatest.*

A particle at the pole is more strongly impelled towards the Earth's centre than a particle at the equator, because the centrifugal force is not appreciable at the pole. But the stronger local attraction *at* the pole has no tendency to cause motion along the surface of the sphere *towards* the pole. There is no impulsion of matter from the equator: the impulsion is all the other way.

This is in effect said (and well said) by Mr. Bakewell's astronomical friend, in the passage already referred to. But while apparently admitting the soundness of the conclusion as applied to a homogeneous sphere, our theorist contends that the revolving sphere ceases to be homogeneous, its component matter, (if I at all understand his drift,) being rendered lighter at the equator by the agency of the centrifugal force. The idea seeming to be, that the Earth is in consequence of this force *specifically lighter* at its equator; so as to cause a preponderating attraction towards the poles, as the regions where the heaviest matter is located.

I really do not know what the ultimate argument is, if it is not this. If I have misconstrued Mr. Bakewell's meaning, I certainly owe him an apology; for the train of thought I have indicated involves a remarkable fusion of ideas.

Weight denotes one of two things. It may either be used to express the quantity of mass in a body, or it may be understood of the amount of downward pressure towards the earth's centre, by which such mass is most commonly measured. The centrifugal force affects the downward pressure, and in this special and limited sense diminishes the *sensible weight* of bodies on the earth's surface; but it has no effect whatever upon their mass, or *inherent weight*. Suppose a very accurate spring balance capable of weighing to a grain, and an equally accurate ounce weight, were made and checked in London, and then carried to the equator. The ounce, tested by the balance (if so nice a test were practicable), would be found about a grain "lighter;" that is to say, the downward pressure upon the spring would be abated by an opposing centrifugal pressure, to the amount of about a grain. But the mass, or inherent weight, of the ounce remains absolutely the same at the equator as it was in the latitude of London. Its power of attracting other particles of matter is not abated a fraction of a grain. Its own gravitation towards the earth's centre (omitting the consideration of the slight increase of radius) is really the same at the equator as it was in London; although the downward pressure *resulting* from this gravitation is reduced by the centrifugal force. To say—

> "The equality of attractive power is disturbed by rotation. The centrifugal force at the equator diminishes the attraction of gravitation or the weight of a body. . . . . The matter at the equator is thus rendered specifically lighter than the matter near the poles, and the mass of the sphere *ceases to be homogeneous*. The attraction exerted by it on a particle of matter placed anywhere . . . between the equator and the pole . . . would therefore be no longer exactly alike. The separate attractions tending to draw the particle towards the equator would cease to be equal in force to the separate attractions in the contrary direction, which counterbalanced them when in a state of rest, &c."—

—seems to evince unconsciousness of the distinctions that exist between vertical pressure, specific weight, inherent power of attraction, and passive gravitation. The whole argument is based upon equivocal middle terms. To such a fallacy the only answer is to give a correct definition of the real meaning of the terms employed.

One word as to the plumb-line. That portion of the earth's centrifugal force which acts in a vertical direction, and opposes the pressure of gravity, has no share whatever in the local deviation of the plumb-line from the perpendicular. This deviation is occasioned by the other, or horizontal element of the centrifugal force, which urges the plumb-bob in the direction of the meridian and towards the equator. In any latitude intermediate between the pole and the equator there will be a trifling deviation: in our hemisphere the plumb-bob will be south of the true perpendicular passing through the point of suspension; in the southern hemisphere the variation will be northwards. The maximum variation of the plumb-line from this cause would occur in latitude 45°, and would amount (roughly speaking) to some five or six angular minutes.

If any one wishes to know whether centrifugal force renders bodies specifically lighter, let him weigh a gyroscope, stand and all, in a scale—first at rest, and afterwards spinning. Or a common top would do as well. In either case, the centrifugal force generated by the spin enormously exceeds that which the gyroscope or top derives from the earth's rotation.

Where terms are not understood in the same sense on both sides, argument ceases to be useful, or indeed, possible. My object has been simply to point out, to such of your readers as may feel any perplexity upon the subject, wherein what I apprehend to be the fallacy of the new theory lies. At the same time, I have endeavoured to give a plain common-sense statement of the matter as I believe it to have been generally understood from Newton downwards.

Charles E. Conder

Forest Hill, August 23rd, 1861.

THE SHEARING STRAINS OF DEFLECTED GIRDERS.

By Homersham Cox, M.A.

I am much obliged by having had my attention drawn to a necessary correction in the short paper on this subject which appeared in the last number of the *Civil Engineer's Journal*. After having shown the effect on the rigidity of a horizontal beam of rectangular section, produced by dividing it into two similar halves by a horizontal section, the paper proceeded thus:—

> "Assuming the ultimate strength of a beam to be proportional to the moment of inertia of its transverse section, it follows also that the breaking weight at the centre of the undivided beam is four times that at the centre of the divided beam."

The ordinary assumption however as to the ultimate strength of a rectangular beam is, that it varies as the square of the depth of the beam, not as the moment of inertia of the transverse section. Consequently, the breaking weight at the centre of the undivided beam is twice (not four times) that at the centre of the divided beam. This correction applies only to the part of the paper relating to strength of beams, and does not effect the part relating to their rigidity.

FOREIGN PUBLICATIONS.

The first quarterly part of the volume for the present year of the *Révue Générale*, of M. César Daly, is now before us, and presents some admirable illustrations, the most artistic being a plan and elevations of one of the ancient altars of the Abbey of St. Denis. This altar, in common with the others which once enriched that abbey, was thrown down at the time of the French Revolution, and broken to fragments. Fortunately the fragments have been recovered, and, what is not less fortunate, a series of drawings have been found, made by M. Pereier in about the year 1797, in which a great deal of the church furniture of the abbey is represented. Guided by these, the experience and taste of M. Viollet le Duc have produced a restoration of the altar, which to judge from the illustration under notice must be one of the most charming bits of work of its kind extant. The other illustrations include some beautiful specimens of antefixæ in terra-cotta from Pompeii; sundry details of roofing tiles, showing various forms and the mode of applying them; several illustrations of a large but commonplace public building, the Maison Eugéne Napolèon, a work which, notwithstanding its very moderate architectural merits, is due to so well-known an architect as M. Hittorff; a portrait of Sir Charles Barry, carefully copied from one taken some years ago in this country; and lastly, an illustration with full details of a very ingenious movable centreing to be made use of in the works for covering the Canal Saint Martin, at Paris, with a vault. The centes for this great work are to be constructed of iron, and to run on rails established for the purpose of carrying them;—three of them connected together form the centreing for a portion of the vault, which when it has served its purpose can be lowered by screw-jacks—run along the rail till it is clear of the covered portion of work, and then raised again, so as to take a fresh section. The idea is an excellent one; but the writer in the review indulges in some criticism (not altogether unreasonable) on the proposed manner of carrying it out, as not presenting the necessary rigidity. A large part of this journal is taken up by the reproduction on its pages of the pamphlet on competitions of which we have already, in our last number, given an account. A detailed account of the competition for the Paris Opera-house is promised, with illustrations of the principal designs submitted.

---

* The centrifugal force, in terms of the force of gravity, is equal to $\frac{R \cos (\text{lat.}) \times \Theta^2}{g}$; R being the earth's radius in feet; Θ, the angular velocity of rotation; and g, 32 and a fraction.

Nouvelles Annales de la Construction.—This journal, part for August, contains announcements of the proposed commencement of extensive additional railway works in France. The total length of the lines of railway, "the execution of which may be considered as having been sanctioned, is 16,946 kilomètres (over 10,000 miles), of which 9448 kilomètres are in working order, and 7492 kilomètres are in hand or have yet to be made." In addition to these it appears that the series of railways forming the third system (*Réseau*) is about to be undertaken. These are enumerated, and comprise twenty-five lines, the majority of which are short ones, the gross mileage being 1325 kilomètres, and the total of the estimates together 367,000,000 francs, giving a mean cost of 277,200 francs per kilomètre. In the selection of these lines, attention has been given, we are told, to the partial completion of the general system of French railways, the connection of centres of production with seaport towns, &c., not however, it is added, losing sight of the precaution necessary for military protection of the frontier.

LIST OF WORKS RECOMMENDED TO CANDIDATES FOR ARCHITECTURAL EXAMINATION.

The following works are recommended by the Council of the Institute of British Architects to gentlemen proposing to become candidates, as containing so much of the information that can be gained from books as is likely to be required in furnishing answers to the question-papers, except upon particular languages and styles that may be selected by candidates. They embrace,—Drawing and Design—Mathematics and Physics—Languages—Professional Practice—Materials and Construction—History and Literature.

Addison, Treatise on Law of Contracts, and Rights and Liabilities ex Contractu. 8vo. 1856.
Amos and Ferard, Treatise on the Law of Fixtures. 8vo. 1847.
Ansted, Elementary Course of Geology. &c. 8vo. 1856.
†Arnott, Elements of Physics. 8vo. 1828.
Baker, Land and Engineering Surveying.* 1859.
Baker, Mensuration.* 1859.
†Baker, Principle and Practice of Statics and Dynamics.* 1851.
Barlow, Treatise on the Strength of Timber, Cast Iron, Malleable Iron, and other Materials: revised by Heather and Willis. 8vo. 1851.
Bartholomew, Specifications for Practical Architecture, &c. 8vo. 1846.
Batissier, Histoire de l'Art Monumentale. 8vo. Paris, 1859.
Bernan, History and Art of Warming and Ventilating Rooms and Buildings. 8vo. 1846.
Brandon, Analysis of Gothic Architecture. 4to. 1847.
Bruff, Engineering Field Work. 8vo. 1840.
†Burnell, Limes, Cements, Mortars, Concretes, Mastics, and Plastering.* 1857.
Castle, Treatise on Land Surveying and Levelling. 8vo. 1845.
Chambers, Treatise on the Decorative Part of Civil Architecture; with Essay on Grecian Architecture by Papworth. Fol. 1826.
†Chevreul, De la Loi du Contraste simultané des Couleurs, &c. 8vo. Paris, 1829 (with plates, 4to. 1839): of this there are abridged translations by Martel, 1854, and by Spanton, 8vo. 1860.
Chitty, Treatise on the Law of Contracts. 8vo. 1857.
Cicognara, Le Fabbriche e i Monumenti cospicui di Venezia. Fol. Venice, 1858.
Cresy, Encyclopædia of Civil Engineering. 8vo. 1856.
†Dobson, Art of Building.* 1859.
†Dobson, Foundations and Concrete Works.* 1850.
†Dobson, Masonry and Stone Cutting.* 1856.
†Dobson, Student's Guide to Measuring and Valuing. 8vo. 1843.
†Donaldson, Handbook of Specifications: with, Glen, a Review of the Law of Contracts. 8vo. 1860.
Fairbairn, On the Application of Cast and Wrought Iron to Building Purposes. 8vo. 1854.
†Fergusson, Handbook of Architecture. 8vo. 1859.
Field, Painter's Art, or a Grammar of Colouring.* 1858.
†Fownes, Rudimentary Chemistry.* 1848.
Fownes, Manual of Elementary Chemistry. 8vo. 1858.
Gailhabaud, Monuments Anciens et Modernes. 4to. Paris, 1842–52.
Gauthier, Les plus beaux Edifices de la Ville de Gênes. Fol. Paris, 1830.
Gibbons, Law of Contracts for Works and Services.* 1857.
Gibbons, Law of Dilapidations and Nuisances. 8vo. 1849.
†Glossary of Terms used in Architecture. 8vo. Oxford, 1851.
Grandjean and Famin, Architecture Toscane. Fol. Paris, 1846.
†Gwilt, Encyclopædia of Architecture. 8vo. 1854.
†Herschel, On Light, Sound, &c. 4to. 1856, &c.
Hittorff, L'Architecture Polychrome. Fol. Paris, 1852.
Hodgkinson, Experimental Researches on Cast Iron. 8vo. 1846.
†Hosking, Architecture and Building Construction. 4to. 1854, &c.
Hutton, a Course of Mathematics. 8vo. 1824; and 8vo. 1841–3.
Inman, Ventilation, Warming, and Transmission of Sound. 8vo. 1836.
Letarouilly, Edifices de Rome Modern. Fol. Paris, 1855.
Loudon, On Gardening, &c. 8vo. 1850.
Lyell, Manual of Elementary Geology. 8vo. 1855; and Supplement, 8vo. 1857.
Malton, Complete Treatise on Perspective. Fol. 1775.
Malton, Young Painter's Maulstick, a Practical Treatise on Perspective. 4to. 1800.
Mauch, Neue Systematische Darstellung der Architektonischen Ordungen. 4to. Dresden, 1850.
Milizia, Vite; or, Lives of Celebrated Architects. Translated by Cresy. 8vo. 1826.
Nicholson, Principles and Practice of Architecture. 8vo. 1848.
Noble, Professional Practice of Architects, and that of Measuring Surveyors, and Reference to Builders. 8vo. 1836.
Normand, Parallel of the Orders of Architecture, edited by Pugin. Fol. 1829.
Palladio, Les Bâtimens et Dessins, edited by Scamozzi. Fol. Vicenza, 1786.
Pasley, a Complete Course of Practical Geometry and Plan Drawing. 8vo. 1828.
Pasley, Limes, Calcareous Cements, Mortars, Stucco, and Concrete, &c. 8vo. 1847.
Pausanias, as a Text Book for the Greek language.
Pliny, Historia Naturalis, Books 34, 35, 36, as a Text Book for the Latin language.
†Portlock, Treatise on Geology.* 1859.
Pugin, True Principles of Pointed or Christian Architecture. 4to. 1841.
Redgrave, Elementary Manual of Colour. 18mo. 1853.
Reid, Young Surveyor's Preceptor: an Analysis of Architectural Mensuration, &c. 4to. 1848.
Repton, Landscape Gardening and Landscape Architecture, edited by Loudon. 8vo. 1842.
Richardson, Observations on the Architecture of England during the Reigns of Elizabeth and James I. 4to. 1837.
Rickman, An Attempt to discriminate the Styles of English Architecture. 8vo. 1848.
Serradifalco, Le Antichità della Sicilia. Fol. Palermo, 1842.
Simms, on Mathematical and Drawing Instruments. 12mo. 1847.
Simms, The Principle and Practice of Levelling. 8vo. 18—.
Society of Dilettanti, Ionian Antiquities. Fol. 1769, 1797, 1840.
Society of Dilettanti, Unedited Antiquities of Attica. Fol. 1833.
Stuart and Revett, Antiquities of Athens. Fol. 1762, 1787, 1794, 1816; and the Unedited Antiquities, by Kinnaird and others. Fol. 1830.
Taylor and Cresy, Architectural Antiquities of Rome. Fol. 1826.
†Tomlinson, Mechanics.* 1859.
†Tomlinson, Introduction to the Study of Natural Philosophy.* 1859.
†Tomlinson, Warming and Ventilation.* 1858.
†Tredgold, Elementary Principles of Carpentry, edited by Barlow. 4to. 1840.
Vitruvius, De Architecturâ.
Watson, Treatise on the Law of Arbitration and Awards. 8vo. 1846.
Wilkins, Prolusiones Architectonicæ. 4to. 1837.
Woodfall, Practical Treatise on the Law of Landlord and Tenant. 8vo. 1856.
The Dictionaries, by Viollet le Duc, and by the Architectural Publication Society in progress.

WORCESTER CATHEDRAL RESTORATION.

This edifice has for a long time been under repair. Recently the choir has been closed, and the nave fitted up for daily service till the choir restorations are completed; a temporary altar being placed at the west end instead of the east, and stalls arranged for the canons, choristers, &c. The restorations, as far as they have proceeded, include a new east window, which has been partly filled with stained glass. The east end has, indeed, been almost entirely rebuilt, and the north-east transept is now undergoing a similar process of restoration, which will take a long time to complete. The south-east transept has just been finished; it is, in fact, almost rebuilt. This transept was until lately blocked up by some Italian arches, which were altogether out of keeping with the Early English style of the choir; but were placed there to support one of the piers standing at the junction of the transept with the aisle. These arches have now been cleared away, and the faulty piers reconstructed. The three walls of the transept have been almost rebuilt, and the mullions and tracery of the windows restored. The piers at the outer angles had become considerably out of the perpendicular, but they have now been carried up straight and strengthened. The carvings which run around the transept in the arcade under the windows, and which are interesting from their great antiquity and singularity, have been restored with the greatest care. The alterations in the transept greatly increase its beauty and apparent altitude. To support the heavy groining during the rebuilding of the walls, a very massive framework of timber was erected by Messrs. Hemming, of Worcester, reaching from the floor to the springing of the groins. This has now been taken down and erected in the corresponding transept on the other side of the choir (the north-east), in order to support its roof in a similar manner.

---

* These form portions of Weale's Rudimentary Treatises.

† These works may be selected as affording an abbreviated, but tolerably complete, course of English reading of an elementary character for students; it being presumed that in each case the reader will be able to discover what portion (if not the whole) of the volume is intended.

At the angle of the west transept, as the workmen were engaged in ascertaining the safety of the foundation, they came upon a series of early Norman arches and pillars, corresponding with those of the crypt, from which a doorway communicated to the portion just discovered, proving that St. Wulstan's crypt must have extended further towards the north than it does at present. The vaulting of the roof was gone, but fragments of it were left at one point or two where it sprang from the shafts. Another discovery has been made at the east transept, on the south side of the cathedral. The steps which led down from the aisle, at the rear of Prince Arthur's tomb, were being carried further back, in order to show the bases of the columns at the angle of the transept, when the workmen found the ancient steps beneath the modern ones; and immediately under one of the steps was a Purbeck marble slab or coffin-lid, representing some distinguished person, the style of whose drapery, and general appearance of the carving, indicate the workmanship of probably the early part of the thirteenth century. The restorations are from the designs and under the direction of Mr. Perkins, 'architect, Worcester. Mr. Bennett, of Birmingham, is the contractor.

SMALL GAS WORKS FOR PRIVATE RESIDENCES AND ISOLATED BUILDINGS.

Within the last few years numerous villages having populations of 1000 inhabitants and upwards have been efficiently lighted with gas, through the medium of limited liability companies, and these undertakings have generally been attended with commercial success. In Scotland even hamlets and much smaller villages than those alluded to have formed companies, and conducted their operations in a more limited but equally advantageous manner; while our transatlantic brethren light up every collection of houses having any pretension to be a town or village, and almost every isolated building has its own gas apparatus. Our attention has recently been directed to an apparatus for the manufacture of coal gas, for use in detached buildings or villages, and which, from the testimony of many who have used it, appears to accomplish its purpose in the most satisfactory manner. The apparatus is almost portable, and is said to be simple in management, and free from most of the ordinary nuisance connected with the manufacture of gas. We allude to the National Coal Gas Apparatus, manufactured by Messrs. Porter and Co., gas engineers, Lincoln, who, although chiefly engaged in the erection of works of magnitude, have constructed a large number of the apparatus referred to within the last two or three years. The retort, which is circular, open at both ends, and tapered from the one end to the other, is fixed horizontally in a nearly square small framework of iron, filled in with brick, for the construction of the furnace (the door of which is at right angles to the retort) and flues, and for the purpose of keeping it firm. At the small end, and on the upper side of the retort, which protrudes slightly from the framework, a small cylinder of cast-iron is fastened perpendicularly, having its mouth closed by an iron cork, ground so as to fit it close, and through the bottom of this a screw, turned by a handle, extends into the retort for about a third or so of its length. At the other end of the retort, which is about flush with the frame, another, but a larger cast-iron cylinder, is fastened. This is also perpendicular to the retort, but extends to the lower side of it, and its mouth stands in a large pan, sunk in the ground and filled with water. On the top of this cylinder is firmly fixed a two-inch cast-iron pipe, which, having two elbows, serves to convey the gas into the purifying portion of the apparatus, which, though not more than four feet in height and two in diameter, contains all that is necessary. From this the gas passes into the holder, which is of the ordinary description. The retort having been made red hot, the gas coal, which is broken small, is shovelled into a kind of funnel, containing about nine pounds weight, and the cork mentioned above being removed, it is poured into the cylinder. The cork is immediately replaced, and the handle working the screw is turned round for one or two minutes. This operation has the effect of sending the coal well into the retort, and after four or five charges are put in at the rate of one every hour or so, supposing the retort to be empty at the commencement of expelling the coke of the first charge down the other cylinder into the water, from whence it is dragged out by means of an instrument made for the purpose, and used to feed the furnace fire. By these very simple contrivances all nuisance is avoided, and though the apparatus does not consume its own smoke, little or no inconvenience is experienced in consequence.

This apparatus was invented by Mr. G. Bower, (who has taken out several patents for gas purposes,) but has been much improved by the present manufacturers, who are the proprietors of the patent. On a recent visit to the works of Messrs. Porter and Co., at Lincoln, we were shown in addition to the above, one of their new apparatus for farm-yard purposes, called the "Universal," in full operation; and from its extreme simplicity, compactness, and general efficiency, we are inclined to express ourselves more favourably of it than of the "National:" the refuse of the household coal-shed can be employed, even to the smallest dust; and the cheapness and portability of the whole affair are great recommendations. The "National" apparatus appears to be more particularly adapted for cannel coal, which gives a gas of greater illuminating power and cleanliness than that obtained from common coal. We can recommend these inventions to the notice of the profession, and to those who wish to obtain a beautiful light, to be produced on their own premises, at a cost stated to be (inclusive of interest on capital invested and labour) one-third or one-fourth that of candles or oil.

NOTES OF THE MONTH.

Chichester Cathedral.—The cathedral of Chichester is again opened for divine service. To adapt it for this purpose the great archway is closed up temporarily. A sufficient sum has not yet been collected for the restoration of the spire. About £30,000 has been gathered, but £20,000 more is required.

Steel Railway Axles.—A large number of steel axles, especially cranked axles, in addition to steel tyres, are now in use on the London and North-Western, North London, and other lines. Of the cranks many are Krupp's, and a considerable number are now being made by Messrs. Naylor, Vickers, and Co., of Sheffield.

The Agricultural Hall, Islington.—This hall, which is intended to accommodate the Annual Smithfield Show, and for other purposes, is about to be commenced, the contract for its construction having been taken for £24,000.

Eastern Bengal Railway.—The works upon this line of railway are now nearly completed. The two principal bridges are over the Echamutty and Koomar rivers, the former having eight, and the latter twelve spans of 80 ft. each. These works are well forward, as are also the stations. The line is expected to be opened by the middle of 1862.

New Church of St. Phillip and St. James, Oxford.—This structure is progressing under the superintendence of the architect, Mr. G. E. Street. Its principal dimensions are, nave 78 ft. by 29 ft.; chancel, 39 ft. by 20 ft.; north and south transepts, each 17 ft. by 16 ft.; north and south aisles, each 78 ft. by 7 ft.; vestry, 13 ft. by 13 ft.; south porch, 8 ft. by 8 ft.. The nave is 35 ft. high to eaves, and 48 ft. to apex of boarded ceiling. The chancel is 20 ft. high to springing of vaulting, and 34 ft. to crown. The tower will be 85 ft. high, surmounted by a spire 55 ft. high. Externally, the ridge of nave will be 58 ft., and that of chancel 55 ft. from ground. The walls are built with Gibraltar stone, faced in the same way inside and out. The dressings are of Box Ground stone, with ornamental courses of red stone. The chancel and steeple are groined in stone throughout. The columns generally, inside, are of Devonshire marble, but those in the main arcades of the nave are of red Aberdeen granite. The work is being executed by Mr. Joseph Castle, builder, of Oxford, whose contract for the whole will amount to about £6500.

The Preservation of Timber.—The success which has attended the employment of Dr. Boucherie's process of impregnating timber with sulphate of copper is well known, but the cost of applying the preservative has hitherto prevented its application to many purposes where the preservation is as important as for railway sleepers and telegraph posts. To remove this impediment Messrs. Dorsett and Blythe have introduced a new and simple method of injection, which is to force into the pores of the wood the antiseptic liquid by means of a vacuum first produced in the pores, and, after the admission of the liquid solution, continued pressure of 120 lb. to 150 lb. on the square inch, in strong close cylinders, that are not acted upon by the sulphuric acid in the salt of copper. The inventors inject the acid solution either hot or cold, without injury to their apparatus, whilst the cost is below that of creosote, the wood is clean and inodorous, is nearly incombustible, and can be worked up for building and other purposes like unprepared wood.

The Proposed Bath Market Improvement.—Seven sets of plans have been submitted in competition for this work, and they are now on view at the Guildhall, Bath. The first prize of £60 has been awarded to Messrs. Hickes and Isaac, of Bath, and the second of £20 to Mr. Green, architect, London.

St. Andrew's Church, Liecester.—The style of this new church is Early English. The ground plan consists of a nave with transepts, a chancel with semicircular apse, and a vestry at the north-east corner. The principal entrances are at the west end, and through a lofty porch on the south side. The church is built almost entirely of brick, the exterior being red, and the interior yellow, and both ornamentally banded with blue. The windows are simple. There is no carving on any of the stonework, but the effect of the whole, both internally and externally, is graceful and pleasing. A chamber for the organ is built over the vestry, and opens into the chancel. The chancel and transepts are separated from the nave by lofty brick arches, and the roof is of very high pitch and wide span.

Stoughton Church, Leicestershire. — The restoration of this church is progressing rapidly under the superintendence of Mr. J. Firn, Leicester. The tower and spire which were found to be unsafe owing to the roots of the trees surrounding the church having disturbed the foundations, have been taken down, and the tower is now rebuilt as far as the middle of the second story. The restoration is being judiciously carried out, every detail being replaced without alteration, and all the sound stones of the original fabric being retained. It is intended shortly to restore the chancel and the body of the church, which are almost equally unsafe with the old tower and spire. The present chancel—though containing sufficient traces of its original appearance to enable a satisfactory restoration to be made—is in a lamentable state.

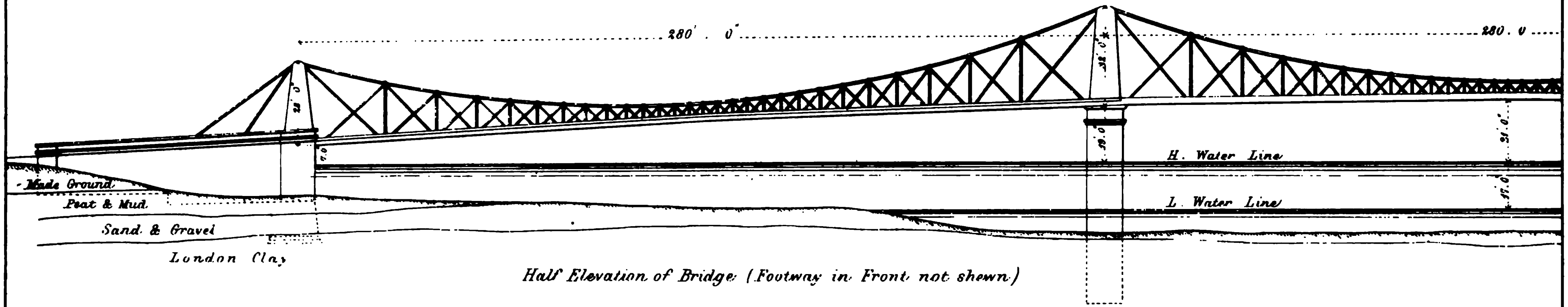
Telluric Currents.—Some time since some highly interesting experiments were made by the Vicomte de Moncel, electrician to the Administration of French Telegraphs, with a view to the further investigation of currents passing through the earth, a subject to which attention had several years ago been drawn by the researches of MM. Palagi and Hogé. M. de Moncel has now published some further observations on the question. Having previously attributed the telluric currents alluded to to the different degrees of moisture at the points where the metallic plates lie buried in the ground, he now examines whether the relative dimensions of the plates may not exercise an influence in the production of currents. To ascertain this experimentally, he dipped a large and a small plate, both of the same metal, into water, and found that a current was produced, going from the large to the small plate. M. de Moncel explains this by the argument that under the influence of the liquid in contact with the plates, the latter are oxidised, and therefore tend to create two opposite currents, whith would neutralise each other did they arise under the same circumstances; but if one of the plates be larger than the other, this is a circumstance which will create a preponderance on one side, and a current will be the consequence. Hence, if two plates be buried in soils of equal humidity a telluric current may take place, provided the plates be unequal in size. He further shows that if two plates of the same metal are polished or scoured unequally, so that the one is more liable to be oxidised than the other, a current will ensue, and that the one which is more subject to oxidisation than the other will furnish the current. This explains why it is difficult not to obtain a current with two plates of equal dimensions buried in a wet soil—viz., because it is extremely difficult to find two plates exactly in the same condition

Statue to the late Sir Charles Barry.—At a meeting of the subscribers to this memorial to Sir Charles Barry, held at the Institute of British Architects on the 12th ult., Mr. Tite, M.P., President, and Treasurer of the Fund, in the chair, the committee reported as follows:—"That the subscription amounted to £946; that they had applied to the Chief Commissioner of Works to be permitted to erect a marble statue in Westminster-hall, at the top of the steps leading to St. Stephen's-hall; that the Hon. W. Cowper expressed his willingness to grant this site, or one outside in Palace-yard, where the statues of Stephenson, Brunel, and Locke were to be erected; that the Committee on the Decoration of the Palace of Westminster had, however, refused the site in Westminster-hall, but suggested and offered the landing at the foot of the staircase in the inner lobby, leading to the committee-rooms, commonly called the 'Witnesses' lobby;' that the commitee recommended the acceptance of this site, and that a marble statue by Mr. Foley, R.A., should be erected at that place." After discussion these recommendations were all adopted, and a sub-committee appointed to carry them into effect.

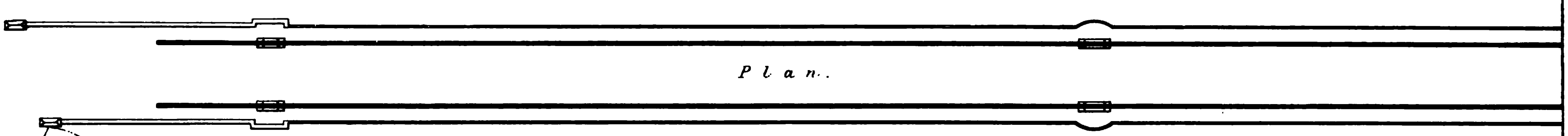
The Proposed New Bridge at Blackfriars.—The design by Mr. Thomas Page, C.E., for, the new bridge at Blackfriars, is one of great boldness and magnificence. It is of combined granite and iron, and enormously massive in all its details. It consists of only three arches, the centre span being 280 ft., or 40 ft. wider than the centre arch of Southwark-bridge; the two side arches are of 220 ft. span each. From the springing of the arch to the crown is a rise of 20 feet. The spandrels of the outer rib on each side are closed, but filled up with figures in the bas-relief and ornamental scroll-work. The cornice beneath the parapet is of bold and handsome design. The piers are four in number, all of granite; each on its extremity is surmounted with a Doric column of polished red granite, 40 feet in height, 23 feet in diameter at base and capital, and 18 feet diameter in the shaft: their capitals reach to the summit of the bridge, and it is proposed to surmount them with colossal groups of statuary. The length is only a few feet greater than that of the present bridge, but its width is 76 feet against 42. There are two footways of 14 feet wide, instead of as now two of 7; and two tramways of 8½ feet each. These are in the centre of the bridge, leaving two roadways of 16 feet each for the light traffic and omnibuses going and coming. The whole area of road and footway is nearly 78,000 feet, instead of 41,000, the area of the present bridge, which cost per square foot of surface £3. 15*s*. 6*d*. The cost is estimated at from £245,000 to £250,000. which is at the rate of rather less than £3. 6*s*. a-foot, or nearly half the price of the present structure. The piers are 28 feet wide by 120 feet long. Two of these are proposed to be constructed in the following manner, as adopted by Mr. Page at new Westminster bridge:—Over the whole area are driven bearing piles of elm, deep into the clay, at intervals of 3 feet apart. Round this cast-iron piles are driven to the greatest depth to which they can be forced. These iron piles are cast with a groove in their side, capable of containing the edge of a slab of granite 2½ feet thick. Between these iron piles these slabs of granite are slid to a depth of nearly 12 feet below the bed of the river, and rising to low-water mark. All the area of the pier thus inclosed is then dredged out between the bearing piles, and the slabs of granite, iron piles, and elm all firmly bolted together by a series of iron tie-rods. The space is then filled in with concrete up to a little below low-water mark, where the courses of solid granite commence. The whole pressure on the foundations would not exceed three tons per foot. The arches are of wrought and cast, iron combined, as in Westminster-bridge. Of the 280 feet span of the centre arch, 100 feet is of wrought-iron. The two smaller arches, of 220 feet, have 70 feet of wrought metal. The approaches are wider and at a much less steep incline than at present, the gradient being reduced from one in 24 to one in 40. The highest part of the proposed structure is a little more than 9 feet lower than the present. The whole surface of the foot and roadways is formed, as at Westminster, by buckle plates of iron, fastened between the ribs. Over this is a layer of blocks of wood and asphalte, and over all the granite pitching. In addition to the design by Mr. Page briefly described, designs have been furnished by Mr. Barlow, Mr. Brereton, Mr. Goodchild, Mr. Brunlees, Mr. Joseph Cubitt, Messrs. E. Bidder and E. Clarke, Mr. R. W. Mylne (grandson of the architect of the present bridge), Mr. Fowler, Mr. Hawkshaw, Mr. G. Rennie and Sir John Rennie: there is little doubt, however, that that by Mr. Page will be the one executed.

NEW BRIDGE ACROSS THE THAMES AT LAMBETH.

P. W. BARLOW, C. E.

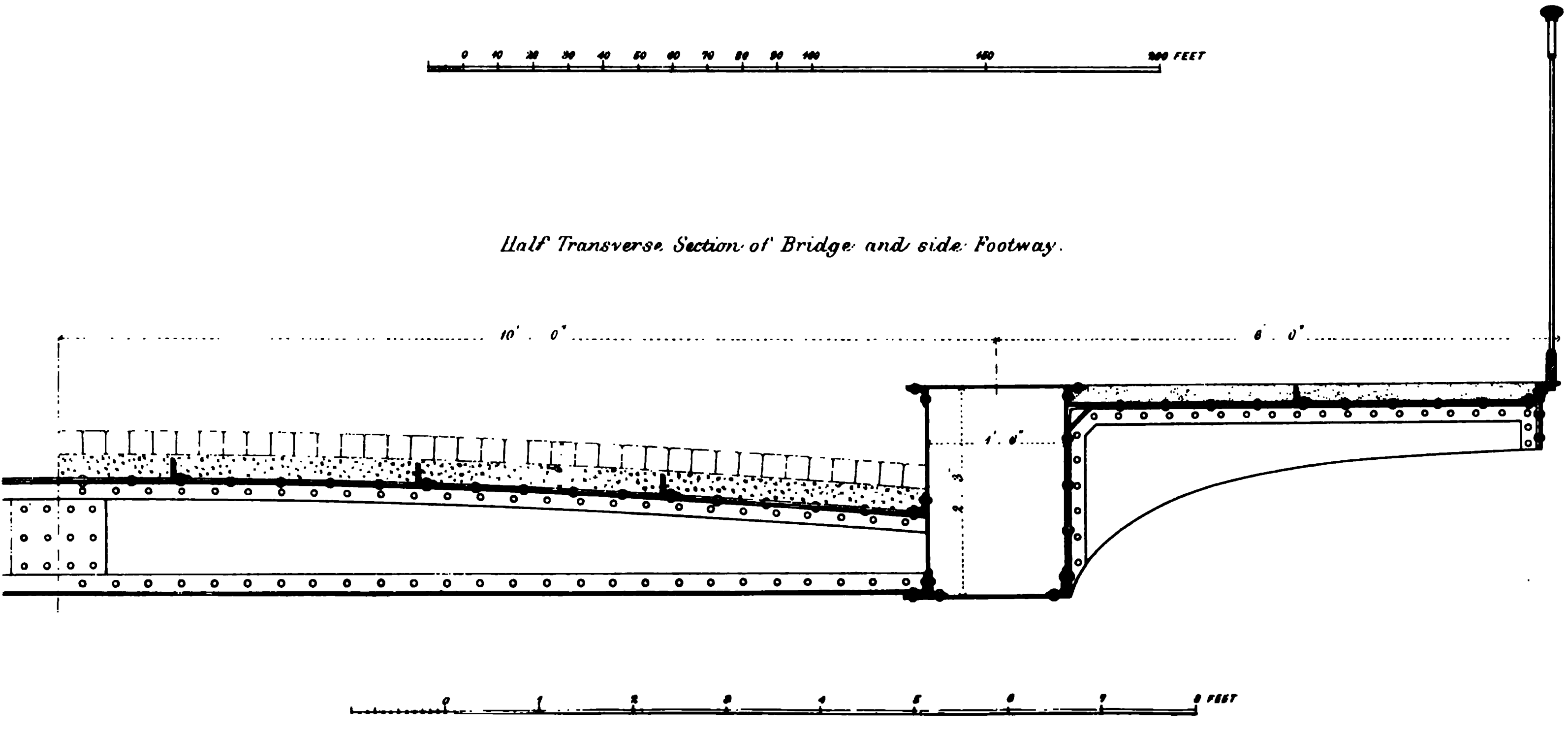


Half Elevation of Bridge (Footway in Front not shown)



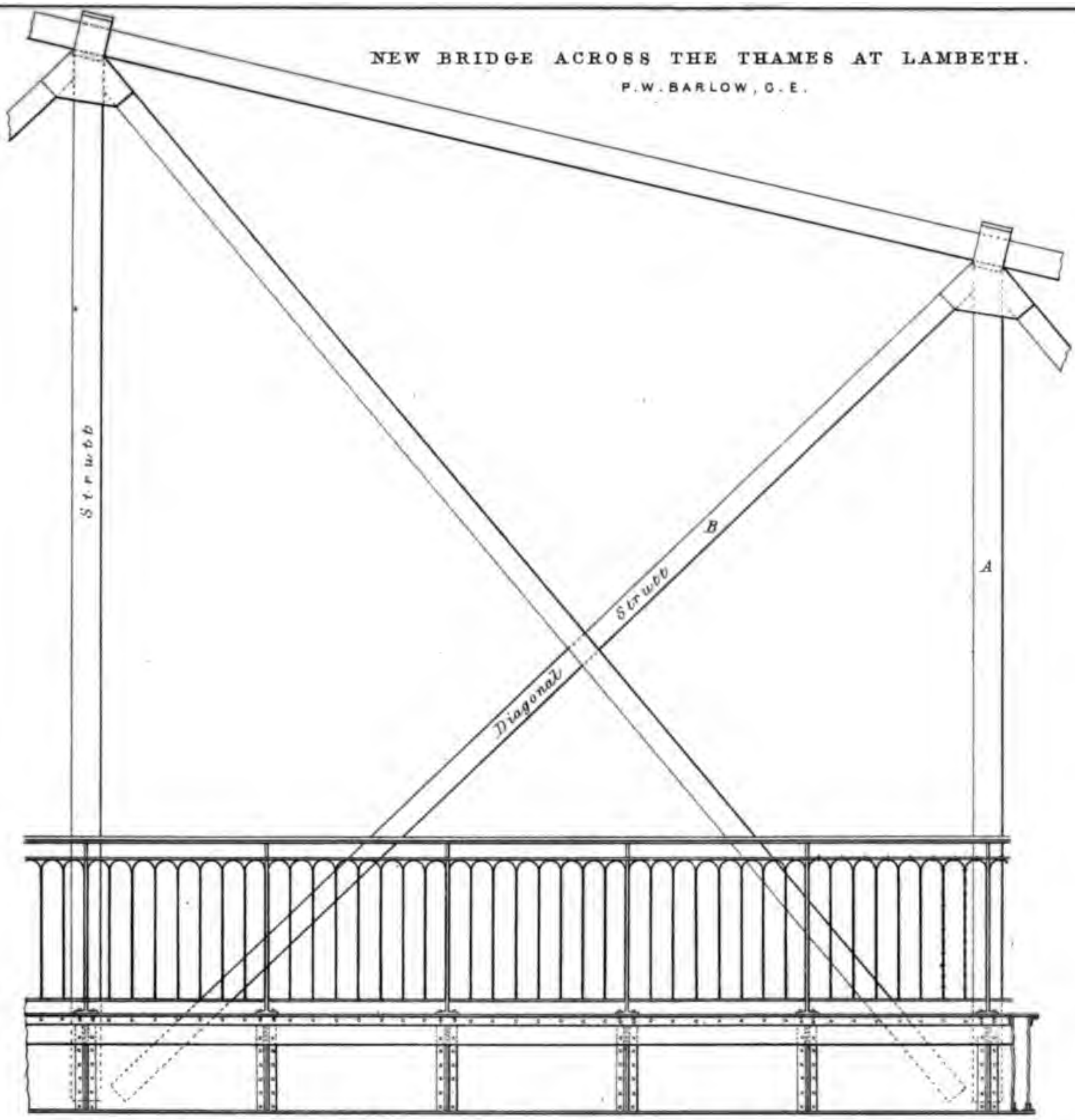
Plan.

Half Transverse Section of Bridge and side Footway.

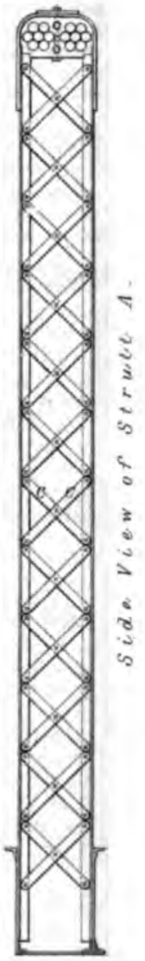


NEW BRIDGE ACROSS THE THAMES AT LAMBETH.

P. W. BARLOW, C. E.

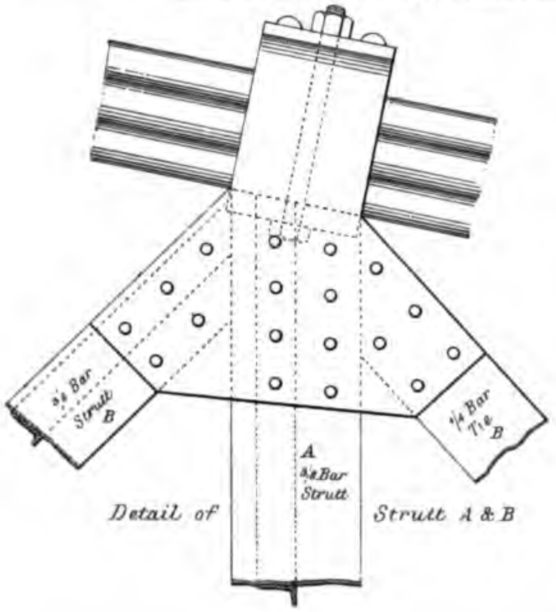


Front Elevation of 1 Bay of Lattice work of Bridge with side Footway in Front.

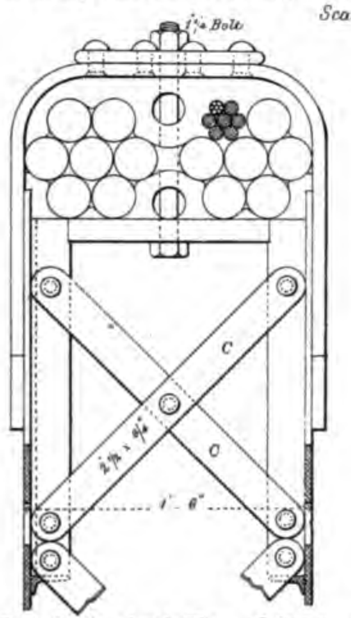


Side View of Strutt A.

Scale ¼ Inch to a Foot

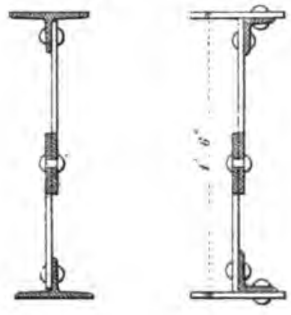


Detail of Strutt A & B



Part Sectional side View of Strutt A.

Section of Lattice Bars C.C.



Scale 1 Inch to a Foot

Octr 1861

J.R.Jobbins

NEW BRIDGE ACROSS THE THAMES AT LAMBETH.

(*With Engravings.*)

The intended new bridge at Lambeth, which is in course of erection by a company incorporated by act of parliament, will connect Church-street, Lambeth, with the Horseferry-road, Westminster. Its construction will be understood by Plates 27 and 28. The site is one proposed by a Committee of the House of Commons, appointed in 1854 to consider the necessity of providing more metropolitan bridges, and a bridge in this situation has been long projected, an act for its construction having been obtained as early as 1836. It has however now become a work of far greater necessity than formerly, from the rapid increase of the neighbourhood.

The bridge will consist of three spans, each of 280 feet, with a clear height of 21 feet at the centre above Trinity high-water mark. The width will be 32 feet, consisting of two footpaths, each 6 feet wide, with a roadway between them of 20 feet, giving two lines of carriageway.

It is estimated that this width is sufficient without pressure or inconvenience to take a traffic equal to double that of Waterloo-bridge; a limit which is not likely to be exceeded while it remains a toll-bridge. The bridge is however designed so that an additional width for two lines of carriageway may be added (making the accommodation equal to that of London-bridge), without interfering with the traffic, whenever it may become desirable. The average inclination of the approaches to the summit of the bridge will be 1 in 27, commencing with an inclination of 1 in 20 for 200 feet on each side. Although this bridge will be constructed on the suspension principle, it will differ from others erected in this country, in having cables of charcoal iron wire, instead of the ordinary wrought-iron links. It will also be distinguished by several important mechanical features.

The platform is composed of wrought-iron plates riveted to longitudinal and transverse wrought-iron beams, so that the roadway forms a horizontal girder of great strength to prevent lateral motion. The platform is suspended to the cable, not by vertical rods, but by rigid lattice sides riveted to the longitudinal beams of the platform. These lattice sides are intended to prevent the longitudinal undulation which necessarily occurs in other suspension bridges supported only by vertical rods. It is further sought to check disturbance by attaching the cables to the standards; and not as hitherto done, to a saddle allowed to move freely on rollers. The standards will be constructed of wrought-iron, and form an essential part of the design, acting in combination with the lattice sides to produce lateral rigidity. This is certainly an original combination. The roadway will be covered with macadamised granite. The use of timber in the roadway platform will thus be entirely avoided.

The employment of iron wire for suspension cables, although new in this country, is frequent on the Continent and in America, and is thought to possess some decided advantages. The superior tensile strength of iron wire as compared with bar-iron is well known. An ultimate strength of 40 tons per inch sectional area is guaranteed for the cables used in this structure, by the ocntractors, Messrs. Newall and Co.

The cables will be four in number, each composed of seven strands; the section of each strand being 3·5 inches. Thus the total section of wire is 98 inches, calculated for a direct tension of 3920 tons.

The total weight of cables is 150 tons, and each strand will not exceed 6 tons in weight. Each strand is composed of seven smaller strands, and each of these latter of seven wires: a fathom length of the cable will weigh about 525 lb., a fathom length of each large strand, 75 lb.

The cable will be manufactured on the spot, each strand strained and delivered from the machine at once to the site on the bridge, and thus the strands will be carried in continuous lengths across the river. The abutments will be brickwork in Portland cement.

The total weight of superstructure for one bay is estimated at 300 tons, the maximum distributed load (at 80 lb. per foot super.) at 300 tons: total 600 tons. This would produce a total horizontal tension on the cables of 875 tons by the ordinary rules. But Mr. Barlow appears to anticipate that this tension will be reduced to one-fifth of the breaking strain by the action of the lattice bars from which the platform is suspended.

The river piers are composed each of two cast-iron cylinders, 12 feet in diameter, driven 25 feet into the bed of ths river, which consists of solid London clay. The cylinders are formed in six segments 9 ft. 6 in. long, with flanges, which are planed so that the surfaces accurately fit, and are thus rendered perfectly watertight. The mode of sinking the cylinders will be similar to that adopted at the Charing Cross-bridge now in course of construction. The cylinders will be filled in to within 4 feet of the level of the bed of the river with Portland cement concrete, and above this level with brickwork laid in good Portland cement. Cast-iron cylinders have generally been filled entirely with concrete, but the engineer has adopted brickwork to provide for the contingency of a fracture of the cylinders, in which case the interior will present a column of brickwork of ample strength to support the structure; in fact the principal duty of the cylinders here is that of a cofferdam, to enable the piers to be constructed. The area of the two cylinders will be 226 square feet, and the greatest weight they will have to carry when the bridge has its maximum load will be 650 tons; the pressure per square foot on the clay will therefore be under 3 tons.

The anchorage or abutments are each composed of a rectangular mass of brickwork and concrete, weighing 1500 tons,—on the Westminster side the clay dips below the level of low-water, and is covered with a bed of gravel, which extends within 5 feet of low-water mark. The foundations for the anchorage will be formed by cast-iron square boxes, flanged and bolted together, and open at both ends, carried down to the gravel, and filled with concrete. These boxes or cells are bolted together, both at the top and bottom, and thus in combination form a horizontal mass of sufficient strength to carry the masonry, and at the same time form the anchor-plate to which the strands of the cables are attached. The Lambeth abutment rests on the gravel without the aid of such boxes, and the cables are attached to massive cast-iron plates on which the brickwork rests.

It is one of the advantages of a wire cable, that an equal tension upon every portion of its section can be secured. Each strand is passed over the standards and down a vertical shaft at the back of each anchorage. A steel link, furnished with a powerful right-handed screw, is attached to the anchor-plate, and a similar link with a left-handed screw to the end of the strand. These screws are received into an octangular barrel screwed at the end to receive the right and left-handed link screws, and thus, by a lever or spanner fitting the octangular barrel, each strand, after being tested to 15 tons per inch of sectional area (double the greatest strain it is expected to undergo) will be adjusted to take its exact position in the bridge.

It only remains now to describe the standards, which are calculated to receive a vertical pressure, and are constructed in boiler-plates, similar to the upper web of ordinary girders. The section of metal allowed is such that the greatest strain from the maximum load will not exceed 2·75 tons per square inch. It is not proposed in the first instance to go to any expense in making them ornamental. If it be hereafter considered advisable to erect towers of an ornamental character, this can be done as a casing to the acting vertical beam or standard, without interfering with the traffic of the bridge.

The following is a statement of the estimated cost:—

The cylinders, at the price paid in similar cases	£5000
The abutments, containing 3000 cubic yards of concrete and brickwork in Portland cement, at an average price of 20*s*. per cubic yard	3000
Cast-iron in square cylinders, anchor plates fixed complete, 100 tons, at £12 per ton	1200
Wrought-iron cables fixed complete	6000
Wrought-iron riveted plates for roadway platform complete, 450 tons, at £20	9000
	£24,200
Road metalling, and other contingencies	3,800
	£28,000

The engineer is Mr. P. W. Barlow, who states in his report to the directors that the works have been let at this sum.

The length of the bridge between the abutments being 840 feet, and the breadth 32 feet, the area will be 26,880 superficial feet. The estimated cost of construction (£28000) would be less than £1. 2*s*. per superficial foot. It is expected that £40,000 will cover the value of property interfered with in the approaches, as well as the cost of the works.

The contractors for the cable are Messrs. Newall and Co. of Gateshead, near Newcastle, and for the execution of the work, Messrs. Porter and Co., of Birmingham. The time of completion mentioned in the contract is August 1862, but the contractors anticipate that the bridge will be open to the public in June next, being an earlier period than the one stipulated in their contract; provided that the approaching winter prove favourable to the uninterrupted prosecution of the works.

THE PROGRESS OF INDIA.

A Parliamentary paper has been recently issued containing a statement exhibiting the moral and material progress and condition of India during the year 1859-60, which presents an account of the character and extent of public works in the course of construction and contemplated, and of the working of those departments of the Indian government that are connected with the arts and manufactures. In a former number of the Journal we noticed the annual Report on the Railways of India, which are only incidentally referred to in the present Parliamentary paper; the public works more particularly mentioned, being the construction of common roads and canals.

The report commences with a narrative of the course of legislation during the year, from which we perceive that Acts were passed for the amendment of the patent law, for enabling joint stock banking companies to be formed on the principle of limited liability, for regulating the establishment and management of electric telegraphs, and for the determination of disputes between workmen engaged on railways and on other public works and their employers. In these Acts there is considerable variation from the Acts of the Imperial legislature, passed for similar objects; some of the alterations having special application to the peculiar circumstances of India. The Act for granting exclusive privileges to inventors, though based on that of the United Kingdom, requires the inventor to submit a petition to the Governor-General in Council, describing the nature of the invention, and to obtain an order before filing his specification; the Governor-General being empowered before making such order to refer the petition for inquiry. This preliminary form is stated to be adopted to check the filing of specifications in frivolous cases, and it is desirable that some such check should be applied to the rapid multiplication of patented inventions in this country. The duration of a patent is for the same term as in England, but the Governor-General may extend it for fourteen years, or he may declare an exclusive privilege to cease. The utmost limit to which the term of a patent can be extended in this country is for seven years. An importer of an invention is not to be allowed exclusive privileges unless he be the actual inventor, and the Act defines an invention to be new if it has not been similarly used or made known in the United Kingdom or in India previously to application for leave to file a specification; but an inventor to whom her Majesty's letters patent has been granted may obtain exclusive privilege to vend the same invention in India if he apply for it within the twelvemonths from the dateof the English patent. The English patent law would be improved by the adoption of some of the more stringent regulations of that of India. The provisions of the electric telegraph act are chiefly peculiar to India. They provide for the punishment of persons engaged in the telegraph department for divulging messages, whether transmitted with or without an express direction for secresy; and the Act renders punishable the offer of a bribe to any person in the employ of the government in the telegraph department.

The number of letters and newspapers that passed through the Indian post-office in the year 1859-60 was considerably less than during the year preceding, the falling off being attributed to the reduction in the number of European troops, and to the absence of commercial activity. This diminution was confined, however, to the north-western provinces, in which the number of articles passing through the post-office was reduced from 18,424,068 in 1859 to 17,367,072 in 1860. The total number in all the presidencies amounted last year to 50,497,999. The book packages increased, and the number of registered letters was also considerably larger than in any previous year, having amounted to 566,424; the proportion of registered letters to the whole correspondence being rather more than one per cent. The financial results of the post-office operations, notwithstanding the falling off of correspondence, have been very satisfactory, and exhibit a surplus of 2,070,109 rupees above the expenditure; the two amounts being, receipts 6,582,903, and the disbursements 4,512,793 rupees. It is not to be expected that in a country like India the same regularity and security can be attained that we are accustomed to in England, and complaints are consequently numerous, 1696 having been recorded during the past year, though the director-general of the post-office asserts that a large proportion of the complaints are groundless, and he observes that in noticing the shortcomings of the post-office department in India, the public are apt to overlook the special difficulties which the post-office in India labours under from the want of efficient sorters and letter carriers. Another source of uncertainty which we have fortunately long since ceased to experience, arises from attacks on the mail carts. During the year not less than fifty robberies of the mails took place, twenty of which occurred in the presidency of Bombay, and in very few instances were the robbers apprehended and punished.

The report of the electric telegraph department exhibits active progress in extending and improving the lines, and increased appreciation of the value of telegraphic communication. The wires last year extended over 10,994 miles, and 136 offices were open for public correspondence, though several offices had been closed during the year, as being no longer necessary for military or political purposes. When the electric telegraph was first established in india, the lines were made on the rough-and-ready system. The posts to support the wires were bamboos, and the instruments for transmitting signals were mere ordinary galvanometers of the simplest construction. The bamboos soon gave place to wood, but the rapid destruction of the posts having occasioned great expense to preserve and replace them, iron standards are being substituted for them all over India, and in the plains it is proposed to erect very lofty iron masts at great distances apart. Experience has proved in India the correctness of what has been contended for by one of the electricians of this country, that the insulation of the wires at the posts is a matter of little consequence, for rain water is a very imperfect conductor of electricity, and the principal thing to be guarded against is actual contact of one wire with another, and with the standards, when made of metal. The insulation of the wires on the Indian lines must indeed be very good, for it is stated that the instruments had been frequently worked direct from Calcutta to Bombay, a distance by the wires of 1600 miles. The instrument generally used is the Morse telegraph; but instead of employing it to impress the message on symbols on a long slip of paper, the messages are transmitted by *sound*. That mode of applying the Morse telegraph had its origin in America, the instrument being literally made to speak at a distance of 1000 miles. This is the last marvel of the electric telegraph, and Dr. O'Shaughnessy, the superintendent of the telegraphs in India, has introduced it there before it has become practically known in England. In this mode of conversing telegraphically the symbols of the Morse alphabet are employed. In the ordinary use of that instrument the "keeper" of an electro-magnet impresses dots and strokes in a single continuous line on a band of paper that is kept moving underneath it; and by the arrangement of those dots and strokes in a diversified manner, all the letters of the alphabet are indicated. In transmitting by sound the ear distinguishes the length of the intervals between the pulsations of the keeper, when it strikes instantaneously to make a dot, and when the contact is prolonged to make a stroke; and in this manner the symbols indicating the different letters are heard. Though this plan of transmission greatly simplifies the use of the Morse telegraph, it is more liable to error, and no record is preserved of the signals actually transmitted. The errors in the transmission of messages in India are not, however, so great as might be expected under such circumstances, for it appears that in the last year not more than one message out of 65 was erroneous, or one word in 1182. The business transacted is rapidly increasing, and one of the most encouraging features connected with it is the increased appreciation of the electric telegraph by the native merchants. The total number of private messages in all India, Pegu, and Ceylon, in 1858-59 was 101,164, and in the succeeding year they amounted to 170,566. The "service" messages, on the contrary, had considerably decreased, in consequence, no doubt, of the more settled state of the country. The increase of the messages sent by native merchants and correspondents was from 39,724 to 71,554; and they increased not only in number, but the average length of the messages sent was much greater. Notwithstanding this satisfactory state of the electric telegraph in India, it does not yet pay its own expenses, though its value to the government is not to be estimated by pounds, shillings, and pence. Dr. O'Shaughnessy complains, somewhat bitterly, of many gross instances of criminal neglect in the persons employed, and he doubts whether that sad drawback to the efficiency of the electric telegraph can ever be obviated until the chief superintendent has power to dismiss the offenders without appeal to the government. On this matter he seems to feel strongly, for he had himself to suffer great personal inconvenience from the gross neglect of a clerk to send him a message from one of the government departments, granting him leave to return to England, which had been rendered necesary by his failing health. At the conclusion of his report Dr. O'Shaughnessy says: "There is a great future before the telegraph in India; by perseverance and determination it should be made the best in the world, inasmuch as it possesses a unity of organisation unattainable elsewhere, with all the resources of the empire to promote its extension and improvement. In two, or at most three years from this time the lines should yield a clear profit, and a uniform minimum charge for messages may then be adopted for all India. This, with the general use of some simple cypher by habitual correspondence, will enable the telegraph to perform much of the present business of the post-office; meanwhile we have at our disposal, at a moderate cost, an instrument of such miraculous power, that by a single message it has already saved our Indian empire; while day by day and hour by hour, it is busy in the promotion of commerce and the furtherance of private interests of every kind."

In the public works department the report regrets that the prominent feature in it is the excessive predominance of expenditure on military works. The aggregate expenditure during the year was 32,221,675 rupees, of which sum 12,394,670 rupees were expended on military and naval objects, and 10,774,545 rupees on internal improvements. Of the latter a great number begun in former years remain unfinished, and have not been proceeded with since financial restriction began to take effect in 1855. In the Punjaub, especially, there are numerous instances where sections of road of excellent construction are interrupted by other sections scarcely passable; there are tunnels half driven, bridges half built or not commenced, though the material is deposited on the site; costly buildings of other kinds are left half finished; there are churches roofless, or otherwise incomplete, and works of irrigation delayed. Many of these undertakings will probably never be completed, and the question now is to select which of them are of most importance, so that the funds at command may be employed in finishing what would not be commenced in the present financial position of India. The Lahore and Peshawur road, which was begun soon after the annexation of the Punjaub, is one of the works which the Governor-General purposes to complete; the result of a late journey to and from Peshawur having "impressed him strongly with its grandeur and unquestionable utility." The whole of the permanent line, with the exception of five bridges, was expected to be open in the course of the present year. The expenditure of a lakh of rupees had also been sanctioned for the repairs of the road from Phillour to Bezas, which had been neglected on account of a projected new road which has since been abandoned. The Baree Doab Canal, on which 90 lakhs of rupees have been expended, has been partially opened, and the works are slowly proceeding, but they will not probably be completed until after the railway, along nearly the same line, is finished. The report mentions several public works which have been suggested to the government, as desirable for the internal improvement, among which was a scheme of Mr. Bourne's for reclaiming and colonising the Sindh Saugor Doab, in the Punjaub, by means of an inundation canal from the Indus; but with so many unfinished works on hand, the Indian Government would be unwise to commence new undertakings, and as regards Mr. Bourne's scheme it was reported against very strongly by the engineers to whom it was referred.

Under the head of ecclesiastical works, the iron church at Rangoon, which was sent out by the home government, is particularly noticed. The cost up to the day of the report had been 62,300 rupees, but it was estimated that the total expense would be 65,000. The defects in the building which it will be requisite to avoid in future structures of the kind, are stated to be that the windows are all fixtures and cannot be opened, that there is a want of verandahs, and an insufficiency of gutters to carry off the rain. The sound of the rain beating on the roof and on the sides of the church was also found to be an annoyance. That portion of the report on public works which relates to railways is principally occupied with noticing the lines recommended by the government to be constructed; but there are one or two points not noticed in the annual Report on the Railways of India that deserve mention. One of these is the failure of the cast-iron sleepers, which, on the recommendation of the late Mr. Rendel, were laid experimentally on the East Indian railway. For a time the road stood very well, but when the express mail trains and heavy coal trains began to pass over it, breakage of the sleepers increased so much that they were removed altogether, and wooden ones were substituted. The opinion of the consulting engineers of the several Indian railways was sought on the subject, and they agreed to a resolution generally unfavourable to cast-iron sleepers, both as regards the ease of motion of trains, and the wear and tear of the rolling stock and of the road itself; but they considered that under certain circumstances, where the ballast is suitable, and where wooden sleepers are not readily procurable, cast-iron sleepers might be applied. The question of making railway stations in India defensible had been brought before the government, and resolutions had been passed to the effect, that, subject to the primary consideration of the convenience of traffic, the buildings should be so erected as to be mutually protective, and that they should be provided with simple and inexpensive facilities for defence. Various other matters connected with the general management of the Indian railways are considered, such as the more severe punishment of negligence by the railway officials, who have in several cases occasioned serious accidents by falling asleep when on duty; the overcrowding of the third-class railway carriages; and the provision of fuel for the engines, of which the north-western provinces promise to afford an ample supply. It appears from the general tenor of the report that other public works in India are for the time considered to be of minor importance to the completion of the railways and electric telegraphs, and while most other undertakings remain unfinished for want of funds, the railways are to be completed and new lines are being surveyed.

FOREIGN PUBLICATIONS.

Nouvelles Annales de la Construction.—A large portion of the September number of this periodical, is taken up by illustrations of the railway stations erecting and about to be erected on the line of railway now in course of construction from Ancona to Bologna: these stations have already been referred to in the *Annales*, and now a report, pointing out the principle upon which they have been arranged, is furnished, illustrated by plans, and other drawings, and worth the attention of those who have the arrangement of such buildings under their control.

Four classes of stations have been designed by Messrs. Oppermann for this line of railway, and we extract part of the descriptive report accompanying them as useful in pointing out the way in which the exigencies of traffic should be taken into account, by the engineer and the architect, in laying down the first lines even of the plan of a railway station. It is almost needless to repeat the observation which we have already had occasion to make more than once, viz., that Continental railway management differs in so many details from English, that it is impossible for a Continental railway station ever to furnish a perfectly serviceable model for an English one. It would be well however, if even only as much forethought, and as timely a recollection of simple and very obvious considerations had been brought to bear upon some of our English stations, as is shown in the accompanying memorandum, and in the four simple plans which illustrate it.

"*Memorandum.*—In the general arrangement of the buildings on the line from Ancona to Bologna the attempt has been made, so far as practicable, to satisfy the following conditions:—

1. A separation of the passenger and goods departments: waiting rooms, refreshment rooms, conveniencies, and telegraph office being towards the right; baggage room, goods offices, and porters' &c. rooms on the left.

2. Making the distance which each traveller has to go over between the times of his entering and leaving the station, as short as possible.

3. Arranging the rooms in an order corresponding with the usual positions of 1st, 2nd, and 3rd class carriages (1st and 2nd classes at the head of the train, and 3rd class behind).

4. Avoiding any confusion of streams of travellers coming in with those going away, by arranging that the exit from the station shall not open upon the entrance lobby.

5. The above precaution is equally desirable in the case of baggage. In 1st-class and 2nd-class stations, baggage is received through one door and given out through a different one.

6. The station-master's office is in immediate contact with all the departments which he has to superintend (booking office, baggage office, postal and telegraph offices, &c.), and near the staircase which leads up to his dwelling.

7. The refreshment rooms are at one end of the station adjoining the waiting rooms, and the conveniences at the same end, detached.

8. In fact, a general correspondence has been established between the positions of the departments of the station, and the order of the carriages, &c., in the train (as standing opposite the platform). The lamp and oil room is opposite the engine, the baggage office opposite the baggage waggons, the 1st and 2nd class waiting-rooms near the head of the train, and the 3rd class near its tail.

9. It is practicable to convert one class of stations into another, by the simple addition or suppression of bays or lengths: to facilitate this the buildings are made to terminate at either end with a plain gable.

10. On the first floor all the rooms are separate, approached from one corridor lighted from its extremity, so that the rooms can be appropriated in any way desired. A kitchen and conveniences are placed at the head of the staircase."

The report, which gives some further details, also observes that it has been judged advantageous to place the refreshment rooms and the conveniences both at the same end of the station, and away from the other offices, as by this arrangement passengers actually in the train do not get confused among the passengers entering it; and the guard, should there be absentees at the moment when he requires to start, has only to go in one direction to look for them. The convenience is also very justly pointed out of having all the parts of each station, whatever its rank and consequent size, arranged in similar relation to each other; the traveller thus always knows beforehand, as if by instinct, in any station on the line, to what part he must go for any particular department.

The usual chronicle of engineering and telegraphic works on hand is given. Among the latter we note an account of an experiment lately tried in the Champs de Mars, to show the possibility of establishing field or flying telegraphs for military purposes. The telegraphic wire and a series of light posts being mounted on a light spring cart, well horsed, and accompanied by mounted artillerymen, the end of the wire was made fast, and the cart started, paying out wire as it went. The first artilleryman stopped at 30 mètres from the starting point, and receiving one of the light poles (which can if preferred be carried like lances by the mounted men,) he twisted the wire round its head, stuck it into the ground, and steadied it by two guys, themselves made fast to pegs driven into the ground. The succeeding posts were fixed at distances of 100 mètres apart, and it was shown that a telegraphic line could be thus temporarily fixed in no more time than that required for the transport of the wire from one point to the other.

Encyclopédie d'Architecture.—We learn from this journal, as in fact from all those published in or treating of the French capital, that the works about to be undertaken this and next year in Paris and the environs, on public buildings alone, are of an unprecedented magnitude, 7 millions of francs (equal roughly to £280,000) being the credits voted for repairs and alterations, additional buildings, and purchases of land, for *nine* only of the public buildings of Paris. It further appears that, in addition the cost of works at the cathedral of Notre Dame alone, up to the end of 1860, was 4,299,424 francs, or very nearly £172,000; and that of this sum the new *flèche* alone (of which some details have already been given by us in a former number) has cost £18,000; and it is further stated that the estimated additional cost of the remaining works now in hand at that cathedral is 1,651,034 francs, or £66,000, giving a total of £238,000 expended chiefly on restorations and decorative works. Let us hope that even after so large a sum has all been expended there will still remain at least some traces of the old work; more than traces we need not hope ever again to be able to detect, for in this great church, as in most of the monuments remaining from the middle ages in France, all the characteristic work of the original founders is being ruthlessly renewed, and all the venerable marks of time are being remorselessly scraped away by the indiscreet zeal of modern restorers.

The following extract from the same journal is on a subject of such practical importance in this country, and one where improvements are so urgently needed by us, that we do not scruple to transfer it unabridged to our columns, without however undertaking to offer any opinion as to the probable success of the experiment if tried in England.

"*Proposed Modification in Smoke Flues.*—Messrs. De Sanges and Masson have addressed a report to the Academy of Sciences relative to a new architectural arrangement intended to introduce a great alteration into our present system of chimneys. The inventors term this a *smoke chamber*. Messrs. De Sanges and Masson fix at the highest point of a building or a house, a chamber into which all the flues from the fireplaces empty themselves: the smoke spreads freely in this space, and escapes from it through a single outlet. In this *smoke chamber* might be fixed either a cistern of water, which would receive sufficient warmth from the smoke to be valuable for household purposes, or a calorifere or air chamber, which could assist in the warming or ventilating of rooms. This system has been applied to an extensive house at Neuilly, says the inventor, and with excellent results.

Eight fireplaces communicating with the common chamber, and lighted together, or in groups of one, two, three, &c., have given a very regular draught under most varying circumstances, and without any gust of wind having ever been able to cause a single one of the eight to smoke.

M. De Sanges details the advantages of his new system as follows: 1. It makes the draught of the chimneys equal and regular. 2. It destroys the effects of wind, which so often makes other chimneys smoke. 3. It enables the architect to dispense with chimney-stacks, so often injurious to the ornamental appearance of buildings, and with all those expensive and dangerous contrivances in sheet-iron, by the help of which we ordinarily struggle against the disturbing power of the wind. 4. It renders the process of sweeping unnecessary. 5. It offers facilities for disconnecting any given flue, in case of fire, or in the summer season. 6. It saves about 50 per cent. of the sum which each householder is forced to pay for the removal of soot from his premises."

◆

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting at Manchester, 1861.

President.—William Fairbairn, F.R.S., LL.D., C.E.

Vice-Presidents.—The Earl of Ellesmere, F.R.G.S.; the Lord Stanley, M.P., D.C.L., F.R.G.S.; the Lord Bishop of Manchester, D.D., F.R.S., F.G.S.; Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S.; Sir Benjamin Heywood, Bart., F.R.S.; Thomas Bazley, M.P.; James Aspinal Turner, M.P.; James Prescott Joule, LL.D., F.R.S.; Joseph Whitworth, F.R.S., M. Inst. C.E.

General Secretary.—Rev. Robert Walker, M.A., F.R.S.

Assistant-General Secretary.—John Phillips, M.A., LL.D., F.R.S., F.G.S.

General Treasurer.—John Taylor, F.R.S.

Local Secretaries.—Robert Dukinfield Darbishire, B.A., F.G.S.; Alfred Neild; Arthur Ransome, M.A.; Professor Henry Enfield Roscoe, B.A.

Local Treasurer.—Robert Phillips Greg, F.G.S.

The Thirty-first Annual Session of the British Association commenced its sittings on the 4th ult., at Manchester, under the presidency of William Fairbairn, LL.D., F.R.S. The gathering of this meeting was much greater than that of last year at Oxford. The tickets sold amounted to 2500, of which 80 were those of life members. The progress of the Association is most gratifying. In 1831 a system of grants of money for scientific purposes was commenced. The sum paid in that year was a very modest one, £20; in 1860-61 it was £1100. This Manchester meeting has been a great success,—taking the average of thirty years, the number of members at each annual gathering has been 1600, and the receipts under £2000. The recent meeting brought together upwards of 3000 members, and the receipts amounted to £3920. Cambridge has been selected as the place of meeting next year, the presidential chair to be occupied by Professor Willis.

The Mayor of Manchester entertained the members at a dinner, after which the company met in the Free Trade Hall, to hold the general meeting, when Lord Wrottesley in resigning the presidency to his successor Mr. William Fairbairn, said: In retiring from the office which I have the honour to hold, it is a great pleasure to me to know that I am to be succeeded by one who is so well worthy of your support. We may derive important instruction from the career of Mr. Fairbairn, whether we view him as a successful engineer or as a distinguished man of science. In the former capacity he is one who, by perseverance, combined with talent, has risen from small beginnings to the summit of his profession; and he forms one of that noble class of men, the Stephensons, the Brunels, the Whitworths, and the Armstrongs, who have conferred such important services upon their country; and some of whom, unfortunately for that country, have perished, alas! too soon, exhausted by their arduous toils. . . Such are men whom we should all delight to honour; and to such a man I resign, with great satisfaction, the chair which I now vacate.

The President's Address.

After a few words of introduction, Mr. Fairbairn said—

A careful perusal of the history of this association will demonstrate that it was the first and for a long time the only institution which brought together for a common object the learned Professors of the Universities and the workers in practical science. The periodical reunions have been of incalculable benefit in giving to practice that soundness of principle and certainty of progressive improvement which can only be obtained by the accurate study of science, and its application to the arts. One the other hand, the men of actual practice have reciprocated the benefits thus derived from theory, in testing by actual experiment deductions which were doubtful, and rectifying those which were erroneous. Guided by an extended experience, and exercising a sound and disciplined judgment, they have often corrected theories apparently accurate, but nevertheless founded on incomplete data or on false assumptions inadvertently introduced. If the British Association had effected nothing more than the removal of the anomalous separation of theory and practice, it would have gained imperishable renown in the benefit thus conferred.

Were I to enlarge on the relation of the achievements of science to the comforts and enjoyments of man, I should have to refer to the present epoch as one of the most important in the history of the world. At no former period did science contribute so much to the uses of life and the wants of society. And in doing this it has only been fulfilling the mission which Bacon, the great father of modern science, appointed for it, when he wrote that "the legitimate goal of the sciences is the endowment of human life with new inventions and riches;" and when he sought for a natural philosophy which, not spreading its energy on barren disquisitions, "should be operative for the benefit and endowment of mankind." Looking then to the fact that, while in our time all the sciences have yielded this fruit; engineering science, with which I have been most intimately connected, has pre-eminently advanced the power, the wealth, and the comforts of mankind, I shall probably best discharge the duties of the office I have the honour to fill by stating as briefly as possible the more recent scientific discoveries which have so influenced the relations of social life. I shall therefore not dwell so much on the progress of abstract science, important as that is, but shall rather endeavour briefly to examine the application of science to the useful arts, and the results which have followed, and are likely to follow, in the improvement of the condition of society.

The history of man throughout the gradations and changes which he undergoes in advancing from a primitive barbarism to a state of civilisation, shows that he has been chiefly stimulated to the cultivation of science and the development of his inventive powers by the urgent necessity of providing for his wants and securing his safety. There is no nation, however barbarous, which does not inherit the germ of civilisation, and there is scarcely any which have not done something towards applying the rudiments of science to the purposes of daily life. Among the South Sea Islanders, when discovered by Cook, the applied sciences—if I may use the term—were not entirely unknown. They had observed something of the motions of the heavenly bodies, and watched with interest their revolutions, in order to apply this knowledge to the division of time. They were not entirely deficient in the construction of instruments of husbandry, of war, and of music. They had made themselves acquainted with the art of shipbuilding and navigation in the construction and management of their canoes. Cut off from the influence of European civilisation, and deprived of intercourse with higher grades of mind, we still find the inherent principle of progression exhibiting itself, and the inventive and reasoning powers developed in the attempt to secure the means of subsistence. Again, if we compare man as he exists in small communities with his condition where large numbers are congregated together, we find that densely populated countries are the most prolific in inventions, and advance more rapidly in science. Because the wants of the many are greater than those of the few there is a more vigorous struggle against the natural limitations of supply, a more careful husbanding of resources, and there are more minds at work. This fact is strikingly exemplified in the history of Mexico and Peru, and its attestation is found in the numerous monuments of the past which are seen in Central America, where the remains of cities and temples and vast public works, erected by a people endowed with high intellectual acquirements, can still be traced. There have been discovered a system of canals for irrigation; long mining galleries cut in the solid rock in search of lead, tin, and copper; pyramids not unlike those of Egypt; earthenware vases and cups, and manuscripts containing the records of their history; all testifying to so high a degree of scientific culture and practical skill, that, looking at the cruelties which attended the conquests of Cortes and Pizarro, we may well hesitate as to which had the stronger claims on our sympathy, the victors or the vanquished.

In attempting to notice those branches of science with which I am but imperfectly acquainted, I shall have to claim your indulgence. This association, as you are aware, does not confine its discussions and investigations to any particular science; and one great advantage of this is, that it leads to the division of labour, while the attention each department receives, and the harmony with which the plan has hitherto worked, afford the best guarantee of its wisdom and proof of its success. In the early history of *Astronomy*, how vague and unsatisfactory were the wild theories and conjectures which supplied the place of demonstrated physical truths and carefully observed laws! How immeasurably small—what a very speck does man appear, with all the wonders of his invention, when contrasted with the mighty works of the Creator; and how imperfect is our apprehension, even in the highest flights of poetic imagination, of the boundless depths of space! These reflections naturally suggests themselves in the contemplation of the works of an Almighty Power, and impress the mind with a reverential awe of the great Author of our existence. The great revolution which laid the foundation of modern astronomy, and which, indeed, marks the birth of modern physical science, is chiefly due to three or four distinguished philosophers. Tycho Brahe, by his system of accurate measurement of the positions of the heavenly bodies; Copernicus, by his history of the solar system; Galileo, by the application of the telescope; and Kepler, by the discovery of the laws of the planetary motions, all assisted in advancing, by prodigious strides, towards a true knowledge of the constitution of the universe. It remained for Newton to introduce, at a later period, the idea of an attraction varying directly as the mass, and inversely as the square of the distance, and thus to reduce celestial phenomena to the greatest simplicity, by comprehending them under a single law. Without tracing the details of the history of this science, we may notice that in more recent times astronomical discoveries have been closely connected with high mechanical skill in the construction of instruments of precision. The telescope has enormously increased the catalogue of the fixed stars, or those "landmarks of the universe," as Sir John Herschel terms them, "which never deceive the astronomer, navigator, or surveyor." The number of known planets and asteroids has also been greatly enlarged. The discovery of Uranus resulted immediately from the perfection attained by Sir William Herschel in the construction of his telescope. More recently, the structure of the nebulæ has been unfolded, through the application to their study of the colossal telescope of Lord Rosse. In all these directions much has been done both by our present distinguished Astronomer Royal, and also by amateur observers in private observatories, all of whom, with Mr. Lassells at their head, are making rapid advances in this department of physical science. Our knowledge of the physical constitution of the central body of our system seems likely, at the present time, to be much increased. The spots on the sun's disk were noticed by Galileo and his contemporaries, and enabled them to ascertain the time of its rotation and the inclination of its axis. They also correctly inferred, from their appearance, the existence of a luminous envelope, in which funnel-shaped depressions revealed a solid and dark nucleus. Just a century ago, Alexander Wilson indicated the presence of a second and less luminous envelope beneath the outer stratum, and his discovery was confirmed by Sir William Herschel, who was led to assume the presence of a double stratum of clouds, the upper intensely luminous, the lower grey, and forming the penumbra of the spots. Observations during eclipses have rendered probable the supposition that a third and outermost stratum of imperfect transparency incloses concentrically the other envelopes. Still more recently, the remarkable discoveries of Kirchoff and Bunsen require us to believe that a solid or liquid photosphere is seen through an atmosphere containing iron, sodium, lithium, and other metals in a vaporous condition. We must still wait for the application of more perfect instruments, and especially for the careful registering of the appearances of the sun by the photoheliograph of Sir John Herschel, so ably employed by Mr. Warren de la Rue, Mr.

Welsh, and others, before we can expect a solution of all the problems thus suggested.

Guided by the same principles which have been so successful in astronomy, its sister science, *Magnetism*, emerging from its infancy, has of late advanced rapidly in that stage of development which is marked by assiduous and systematic observation of the phenomena, by careful analysis and presentation of the facts which they disclose, and by the grouping of these in generalisations, which, when the basis on which they rest shall be more extended, will prepare the way for the conception of a general physical theory, in which all the phenomena shall be comprehended, while each shall receive its separate and satisfactory explanation. It is unnecessary to remind you of the deep interest which the British Association has at all times taken in the advancement of this branch of natural knowledge, or of the specific recommendations which, made in conjunction with the Royal Society, have been productive of such various and important results. To refer but to a single instance; we have seen those magnetic disturbances, so mysterious in their origin and so extensive in simultaneous prevalence,—and which, less than 20 years ago, were designated by a term specially denoting that their laws were wholly unknown;—traced to laws of periodical recurrence, revealing, without a doubt, their origin in the central body of our system, by inequalities which have for their respective periods the solar day, the solar year, and, still more remarkably, and until lately unsuspected solar cycle of about 10 of our terrestrial years, to whose existence they bear testimony in conjunction with the solar spots, but whose nature and causes are in all other respects still wrapped in entire obscurity. We owe to General Sabine, especially, the recognition and study of these and other solar magnetic influences and of the magnetic influence of the moon, similarly attested by concurrent determinations in many parts of the globe, which are now held to constitute a distinct branch of this science, not inappropriately named "celestial," as distinguished from purely terrestrial magnetism.

We ought not in this town to forget that the very rapid advance which has been made in our time in *Chemistry*, is due to the law of equivalents, or atomic theory, first discovered by our townsman, John Dalton. Since the development of this law its progress has been unimpeded, and it has had a most direct bearing on the comforts and enjoyments of life. A knowledge of the constituents of food has led to important deductions as to the relative nutritive value and commercial importance of different materials. Water has been studied in reference to the deleterious impurities with which it is apt to be contaminated in its distribution to the inhabitants of large towns. The power of analysis, which enables us to detect adulterations, has been invaluable to the public health, and would be much more so if it were possible to obviate the difficulties which have prevented the operation of recent legislation on this subject. We have another proof of the utility of this science in its application to medicine; and the estimation in which it is held by the medical profession is the true index of its value in the diagnosis and treatment of disease. The largest developments of chemistry, however, have been in connection with the useful arts. What would now be the condition of calico-printing, bleaching, dying, and even agriculture itself, if they had been deprived of the aid of theoretic chemistry? For example, aniline—first discovered in coal tar by Dr. Hoffman, who has so admirably developed its properties—is now most extensively used as the basis of red, blue, violet, and green dyes. This important discovery will probably in a few years render this country independent of the world for dye-stuffs; and it is more than probable that England, instead of drawing her dye-stuffs from foreign countries, may herself become the centre from which all the world will be supplied. It is an interesting fact, that at the same time, in another branch of this science, M. Taurnet has lately demonstrated that the colours of gems, such as the emerald, aqua-marina, amethyst, smoked rock crystal, and others are due to volatile hydrocarbons, first noticed by Sir David Brewster in clouded topaz, and that they are not derived from metallic oxides, as has been hitherto believed. Another remarkable advance has recently been made by Bunsen and Kirchoff in the application of the coloured rays of the prism to analytical research. We may consider their discoveries as the commencement of a new era in analytical chemistry, from the extraordinary facilities they afford in the qualitative detection of the minutest traces of elementary bodies. The value of this method has been proved by the discovery of the new metals cæsium and rubidium, by M. Bunsen, and it has yielded another remarkable result, in demonstrating the existence of iron and six other known metals in the sun. In noticing the more recent discoveries in this important science, I must not pass over in silence the valuable light which chemistry has thrown upon the composition of iron and steel. Although Despretz demonstrated many years ago that iron would combine with nitrogen, yet it was not until 1857 that Mr. C. Binks proved that nitrogen is an essential element of steel, and more recently M. Caron and M. Fremy have further elucidated this subject; the former showing that cyanogen, or cyanide of ammonium, is the essential element which converts wrought-iron into steel; the latter combining iron with nitrogen through the medium of ammonia, and then converting it into steel by bringing it at the proper temperature into contact with common coal gas. There is little doubt that in a few years these discoveries will enable Sheffield manufacturers to replace their present uncertain, cumbrous, and expensive process, by a method at once simple and inexpensive, and so completely under control, as to admit of any required degree of conversion being obtained with absolute certainty. Mr. Crace Calvert, also, has proved that cast iron contains nitrogen, and has shown that it is a definite compound of carbon and iron mixed with various proportions of metallic iron, according to its nature. Before leaving chymical science, I must refer to the interesting discovery by M. Deville, by which he succeeded in rapidly melting 38 or 40 lb. of platinum—a metal till then considered almost infusible. This discovery will render the extraction of platinum from the ore more perfect, and, by reducing its cost, will greatly facilitate its application to the arts.

It is little more than half a century since *Geology* assumed the distinctive character of a science. Taking into consideration the aspects of nature in different epochs of the history of the earth, it has been found that the study of the changes at present going on in the world around us enables us to understand the past revolutions of the globe, and the conditions and circumstances under which strata have been formed and organic remains imbedded and preserved. The geologist has increasingly tended to believe that the changes which have taken place on the face of the globe, from the earliest times to the present, are the result of agencies still at work. But while it is his high office to record the distribution of life in past ages, and the evidence of physical changes in the arrangement of landand water, his results hitherto have indicated no traces of its beginning, nor have they afforded evidence of the time of its future duration. Geology has been indebted for this progress very largely to the investigations of Sedgewick, and the writings of Sir Charles Lyell. As an example of the application of geology to the practical uses of life, I may cite the discovery of the goldfields of Australia, which might long have remained hidden but for the researches of Sir Roderick Murchison in the Ural mountains, on the geological position of the strata from which the Russian gold is obtained. From this investigation he was led by inductive reasoning to believe that gold would be found in similar rocks, specimens of which had been sent him from Australia. The last years of the active life of this distinguished geologist have been devoted to the re-examination of the rocks of his native Highlands of Scotland. Applying to them those principles of classification which he long since established, he has demonstrated that the crystalline limestone and quartz rocks which are associated with mica schists, &c., belong by their imbedded organic remains to the Lower Silurian Rocks. Descending from this well-marked horizon, he shows the existence beneath all such fossiliferous strata of vast masses of sandstone and conglomerate of Cambrian age; and lastly he has proved the extstence of a fundamental gneiss, on which all the other rocks repose, and which, occupying the north-western Hebrides, and the west coasts of Sutherland and Ross, is the oldest rock formation on the British Isles, it being unknown in England, Wales, or Ireland. It is well known that the temperature increases as we descend through the earth's crust, from a certain point near the surface, at which the temperature is constant. In various mines, borings, and artesian wells the temperature has been found to increase about 1 deg. Fahrenheit for every 60 or 65 feet of descent. In some carefully conducted experiments during the sinking of Dukinfield Deep Mine—one of the deepest pits in this country—it was found that a mean increase of about 1 deg. in 71 feet occurred. If we take the ratio thus indicated, and assume it to extend to much greater depths, we should reach, at two-and-a-half miles from the surface, strata at the temperature of boiling water; and at depths of about 50 or 60 miles the temperature would be sufficient to melt, under the ordinary pressure of the atmosphere, the hardest rocks. Reasoning from these facts, it would appear that the mass of the globe, at no great depth, must be in a fluid state. But this deduction requires to be modified by other considerations, namely, the influence of pressure on the fusing point, and the relative conductivity of the rocks which form the earth's crust. To solve these questions, a series of important experiments were instituted by Mr. Hopkins, in the prosecution of which Dr. Joule and myself took part; and after a long and laborious investigation it was found that the temperature of fluidity increased about 1 deg. Fahrenheit for every 500 lb. of pressure in the case of spermaceti, bees'-wax, and other similar substances. However, on extending these experiments to less compressible substances, such as tin and barytes, a similar increase was not observed. But this series of experiments has been unavoidably interrupted; nor is the series on the conductivity of rocks entirely finished. Until they have been completed by Mr. Hopkins we can only make a partial use of them in forming an opinion of the thickness of the earth's solid crust. Judging, however, alone from the greater conductivity of the igneous rocks, we may calculate that the thickness cannot possibly be less than nearly three times as great as that calculated on the usual suppositions of the conductive power of the terrestrial mass at enormous depths being no greater than that of the superficial sedimentary beds. Other modes of investigation which Mr. Hopkins has brought to bear on this question appear to lead to the conclusion that the thickness of the earth's crust is much greater even than that above stated. This would require us to assume that a part of the heat in the crust is due to superficial and external rather than central causes. This does not bear directly against the doctrine of central heat, but shows that only a part of the increase of temperature observed in mines and deep wells is due to the outward flow of that heat.

Touching those highly interesting branches of science, *Botany* and *Zoology*, it may be considered presumptuous in me to offer any remarks. I have, however, not entirely neglected in my earlier days to inform myself of certain portions of natural history, which cannot but be attractive to all who delight in the wonderful beauties of natural objects. How interesting is the organisation of animals and plants—how admirably adapted to their different functions and spheres of life. They want nothing, yet have nothing superfluous. Every organ is adapted perfectly to its functions; and the researches of Owen, Agassiz, Darwin, Hooker, Daubeney, Babington, and Jardine, fully illustrate the perfection of the animal and vegetable economy of nature.

Two other important branches of scientific research, *Geography* and *Ethnology*, have for some years been united in this association in one section, and that probably the most attractive and popular of them all. We are much indebted to Sir Roderick Murchison, among other members of the association, for its continued prosperity, and the high position it has attained in public estimation. The spirit of enterprise, courage, and perseverance displayed by our travellers in all parts of the world have been powerfully stimulated and well supported by the Geographical Society; and the preminence and rapid publicity given to discoveries by that body have largely promoted geographical research. In physical geography the late Baron von Humboldt has been one of the largest contributors, and we are chiefly indebted to his personal researches and numerous writings for the elevated position it now holds among the sciences, To Humboldt we owe our knowledge of the physical features of Central and Southern America. To Parry, Sir James Ross, and Scoresby we are indebted for discoveries in the Arctic and Antarctic regions. Geography has also been advanced by the first voyage of Franklin down the Copper Mine River, and along the inhospitable shores of the Northern Seas, as far as Point Turn-again ; as also by that ill-fated expedition in search of a North-West passage, followed by others in search of the unfortunate men who perished in their attempt to reach those ice-bound regions, so often stimulated by the untiring energy of a high-minded woman. In addition to these, the discoveries of Dr. Livingstone in Africa have opened to us a wide field of future enterprise along the banks of the Zambesi and its tributaries. To these we may add the explorations of Captain Burton in the same continent, and those also by Captain Speke and Captain Grant, of a hitherto unknown region, in which it has been suggested that the White Nile has its source, flowing from one of two immense lakes, upwards of 300 miles long by 100 broad, and situated at an elevation of 4000 feet above the sea. To these remarkable discoveries I ought to add an honourable mention of the sagacious and perilous exploration of Central and Northern Australia by Mr. M'Donald Stuart.

Having glanced, however imperfectly, at some of the most important branches of science which engage the attention of members of this association, I would now invite attention to the *Mechanical Sciences*, with which I am more familiarly acquainted. They may be divided into theroetical mechanics and dynamics, comprising the conditions of equilibrium and the laws of motion; and applied mechanics, relating to the construction of machines. I have already observed that practice and theory are twin sisters, and must work together to insure a steady progress in mechanical art. Let us, then, maintain this union as the best and safest basis of national progress, and moreover, let us recognise it as one of the distinctive aims of the annual reunions of this association During the last century the science of applied mechanics has made strides which astonish us by their magnitude; but even these, it may reasonably be hoped, are but the promise of future and more wonderful enlargements. I therefore propose to offer a succinct history of these improvements, as an instance of the influence of scientific progress on the wellbeing of society. I shall take in review the three chief aids which engineering science has afforded to national progress—namely, canals, steam navigation, and railways; each of which has promoted an incalculable extension of the industrial resources of the country.

One hundred years ago, the only means for the conveyance of inland merchandise were the packhorses and waggons on the then imperfect highways. It was reserved for Brindley, Smeaton, and others to introduce a system of canals, which opened up facilities for an interchange of commodities at a cheap rate over almost every part of the country. The impetus given to industrial operations by this new system of conveyance induced capitalists to embark in trade, in mining, and in the extension of manufactures, in almost every district. These improvements continued for a series of years, until the whole country was intersected by canals requisite to meet the demands of a greatly extended industry. But canals, however well adapted for the transport of minerals and merchandise, were less suited for the conveyance of passengers. The speed of the canal boats seldom exceeded from two and a half to three miles an hour, and in addition to this, the projectors of canals sometimes sought to take an unfair advantage of the Act of Parliament, which fixed the tariff at so much per ton per mile, by adopting circuitous routes, under the erroneous impression that mileage was a consideration of great importance in the success of such undertakings. It is in consequence of short-sighted views and imperfect legislation that we inherit the numerous curves and distortions of our canal system. These defects in construction rendered canals almost useless for the conveyance of passengers, and led to the improvement of the common roads and the system of stage coaches; so that before the year 1830 the chief public highways of the country had attained a remarkable smoothness and perfection; and the lightness of our carriages and the celerity with which they were driven still excite the admiration of those who remember them.

These days of an efficiently worked system, which tasked the power and speed of the horse to the utmost, have now been succeeded by changes more wonderful than any that previously occurred in the history of the human race. Scarcely had the canal system been fully developed, when a new means of propulsion was adopted—namely, steam. I need not recount to you the enterprise, skill, and labour that have been exerted in connexion with steam navigation. You have seen its results on every river and on every sea; results we owe to the fruitful minds of Miller, Symington, Fulton, and Henry Bell, who were the pioneers in the great march of progress. Viewing the past, with a knowledge of the present and a prospect of the future, it is difficult to estimate sufficiently the benefits that have been conferred by this application of mechanical science to the purposes of navigation. Power, speed, and certainty of action have been attained on the most gigantic scale. The celerity with which a modern steamer, with a thousand tons of merchandise and some hundreds of human beings on board, cleaves the water and pursues her course, far surpasses the most sanguine expectations of a quarter of a century ago, and indeed, almost rivals the speed of the locomotive itself. Previous to 1812 our intercourse with foreign countries and with our colonial possessions depended entirely upon the state of the weather. It was only in favourable seasons that a passage was open; and we had often to wait days, or even a week, before Dublin could be reached from Holyhead; now this distance of 63 miles is accomplished in all weathers in little more than three hours. The passage to America used to occupy six weeks or two months; now it is accomplished in eight or nine days. The passage round the Cape to India is reduced from nearly half a year to less than a third of that time, while that country may be reached by the overland route in less than a month. These are a few of the benefits derived from steam navigation, and, as it is yet far from perfect, we may reasonably calculate on still greater advantages in our intercourse with distant nations. I will not here enter upon the subject of the numerous improvements which have so rapidly advanced the progress of this important service. Suffice it to observe, that the paddlewheel system of propulsion has maintained its superiority over every other method yet adopted for the attainment of speed, as by it the best results are obtained with the least expenditure of power. In ships of war the screw is indispensable, on account of the security it affords to the engines and machinery, from their position in the hold below the water-line, and because of the facility it offers in the use of sails, when the screw is raised from its position in the well to a recess in the stern prepared for that purpose. It is also preferrable in ships which require auxiliary power in calms and adverse winds, so as to expedite the voyage, and effect a considerable saving upon the freight.

The public mind had scarcely recovered itself from the changes which steam navigation had caused, and the impulse it had given to commerce, when a new and even more gigantic power of locomotion was inaugurated. Less than a quarter of a century had elapsed since the first steamboats floated on the waters of the Hudson and the Clyde, when the achievements thence resulting were followed by the application of the same agency to the almost superhuman flight of the locomotive and its attendant train. I well remember the competition at Rainhill in 1830, and the incredulity everywhere evinced at the proposal to run locomotives at twenty miles an hour. Neither George Stephenson himself, nor any one else, had at that time the most distant idea of the capabilities of the railway system. On the contrary, it was generally considered impossible to exceed ten or twelve miles an hour; and our present high velocities, due to high-pressure steam and the tubular system of boilers, have surpassed the most sanguine expectations of engineers. The sagacity of George Stephenson at once seized upon the suggestion of Henry Booth to employ tubular boilers; and that united to the blast pipe, previously known, has been the means of effecting all the wonders we now witness in a system that has done more for the development of practical science and the civilisation of man than any discovery since the days of Adam.

From a consideration of the changes which have been effected in the means for the interchange of commodities, I pass on to examine the progress which has been made in their production. And, as the steam-engine has been the basis of all our modern manufacturing industry, I shall glance at the steps by which it has been perfected. Passing over the somewhat mythical fame of the Marquis of Worcester and the labours of Savery, Beighton, and Newcomen, we come at once to discuss the state of mechanical art at the time when James Watt brought his gigantic powers to the improvement of the steam-engine. At that time the tools were of the rudest construction, nearly everything being done by hand, and, in consequence, wood was much more extensively employed than iron. Under these circumstances Watt invented separate condensation, rendered the engine double acting, and converted its rectilinear motion into a circular one, suitable for the purposes of manufacture. But the discovery at first made but little way, the public did not understand it; and a series of years elapsed before the difficulties, commercial and mechanical, which opposed its application, could be overcome. When the certainty of success had been demonstrated, Watt was harassed by infringements of his patent, and lawsuits for the maintenance of his rights. Inventors and pretended inventors set up claims, and entered into combination with manufacturers, miners, and others, to destroy the patent and deprive him of the just fruits of his labour and genius. Such is the selfish heartlessness of mankind in dealing with discoveries not their own, but from which they expect to derive benefit. The steam-engine, since it was introduced by Watt, has changed our habits in almost every condition of life. Things which were luxuries have become necessaries, and it has given to the poor man in all countries in which it exists a degree of comfort and independence and a participation in intellectual culture unknown before its introduction. It has increased our manufactures tenfold; and has lessened the barriers which time and space interpose. It ploughs the land, and winnows and grinds the corn. It spins and weaves our textile fabrics. In mining it pumps, winds, and crushes the ores. It performs these things with powers so great and so energetic as to astonish us at their immensity, while they are at the same time perfectly docile, and completely under human control. In war it furnishes the means of aggression, as in peace it affords the bonds of conciliation; and, in fact, places within reach a power which, properly applied, produces harmony and goodwill among men, and leads to the happiest results in every condition of human existence. We may, therefore, well be proud of the honour conferred on this country as the cradle of its origin, and as having fostered its development from its earliest applications to its present high state of perfection. I cannot conclude this notice of the steam-engine without observing the changes it is destined to effect in the cultivation of the soil. It is but a short time since it was thought inapplicable to agricultural purposes, from its great weight and expense. But more recent experience has proved this to be a mistake, and already in most districts we find that it has been pressed into the service of the farm. The small locomotive, mounted on a frame with four wheels, travels from village to village with its attendant, the thrashing machine, performing the operations of thrashing, winnowing, and cleaning, at less than one-half the cost by the old and tedious process of hand-labour. Its application to ploughing and tillage on a large scale is, in my opinion, still in its infancy, and I doubt not that many members of this association will live to see the steam plough in operation over the whole length and breadth of the land. Much has to be done before this important change can be successfully accomplished; but, with the aid of the agriculturist in preparing the land so as to meet the requirements of steam machinery, we may reasonably look forward to a new era in the cultivation of the soil.

The extraordinary developments of practical science in our system of textile manufacture are, however, not entirely due to the steam-engine, although they are now in a great measure dependent on it. The machinery of these manufactures had its origin before the steam-engine had been applied except for mining purposes; and the inventions of Arkwright, Hargreaves, and Crompton were not conceived under the impression that steam would be their moving power. On the contrary, they depended upon water; and the cotton machinery of this district had attained considerable perfection before steam came to the aid of the manufacturer, and ultimately enabled him to increase the production to its present enormous extent. I shall not attempt a description of the machinery of the textile manfactures, because ocular inspection will be far more acceptable. I can only refer you to a list of establishments in which you may examine their operations on a large scale, and which I earnestly recommend to your attention. I may, however, advert to a few of the improvements which have marked the progress of the manufacturing system in this country. When Arkwright patented his water-frames in 1767, the annual consumption of cotton was about 4,000,000 lb. weight. Now it is 1,200,000,000 lb. weight—300 times as much. Within half a century the number of spindles at work, spinning cotton alone, has increased tenfold; while by superior mechanism each spindle produces 50 per cent. more yarn than on the old system. Hence the importance to which the cotton trade has risen, equalling at the present time the whole revenue of the three kingdoms, or £70,000,000 sterling per annum. As late as 1820 the power-loom was not in existence; now it produces about 14,000,000 yards of cloth, or, in more familiar terms, nearly 8000 miles of cloth per diem. I give these particulars to show the immense power of production of this country, and to afford some conception of the number and quality of the machines which effect such wonderful results. Mule spinning was introduced by Crompton, in 1787, with about 20 spindles to each machine. The powers of the machine were, however, rapidly increased; and now it has been so perfected that 2000, or even 3000 spindles are directed by a single person. At first the winding on, or forming the shape of the cop, was performed by hand; but this has been superseded by rendering the machine automatic, so that it now performs the whole operation of drawing, stretching, and twisting the thread, and winding it on to the exact form, ready for the reel or shuttle as may be required. These and other improvements in carding, roving, combing, spinning, and weaving, have established in this country an entirely new system of industry; it has given employment to greatly increased numbers, and a more intelligent class of work-people. Similarly important improvements have been applied to the machinery employed in the manufacture of silk, flax, and wool; and we have only to watch the processes in these different departments to be convinced that they owe much to the development of the cotton manufacture. In the manufacture of worsted, the spinning-jenny was not employed at Bradford until 1790, nor the power-loom until about 1825. The production of fancy or mixed goods from alpaca and mohair wool, introduced to this country in 1836, is, perhaps, the most striking example of a new creation in the art of manufacture, and is chiefly due to Mr. Titus Salt, in whose immense palace of industry, at Saltaire, it may be seen in the greatest perfection. In flax machinery the late Sir Peter Fairbairn was one of the most successful inventors, and his improvements have contributed to the rapid extension of this manufacture.

I might greatly extend this description of our manufacturing industry, but I must for the present be brief, in order to point out the dependence of all these improvements on the iron and coal so widely distributed among the mineral treasures of our island. We are highly favoured in the abundance of these minerals, deposited with an unsparing hand by the great Author of Nature under so slight a covering as to bring them within reach of the miner's art. To them we owe our present high state of perfection in the useful arts; and to their extended application we may safely attribute our national progress and wealth. So that, looking to the many blessings which we daily and hourly receive from these sources alone, we are impressed with devotional feelings of gratitude to the Almighty for the manifold bounties He has bestowed on us.

Previously to the inventions of Henry Cort, the manufacture of wrought-iron was of the most crude and primitive description. A hearth and a pair of bellows was all that was employed. But since the introduction of puddling, the iron-masters have increased the production to an extraordinary extent, down to the present time, when processes for the direct conversion of wrought-iron on a large scale are being attempted. A consecutive series of chemical researches into the different processes, from the calcining of the ore to the production of the bar, carried on by Dr. Percy and others, has led to a revolution in the manufacture of iron; and although it is at the present moment in a state of transition, it nevertheless requires no very great discernment to perceive that steel and iron of any required tenacity will be made in the same furnace, with a facility and certainty never before attained. This has been effected to some extent by improvements in puddling; but the process of Mr. Bessemer—first made known at the meetings of this association at Cheltenham—affords the highest promise of certainty and perfection in the operation of converting the melted pig direct into steel or iron, and is likely to lead to the most important developments in this manufacture. These improvements in the production of the material must, in their turn, stimulate its application on a larger scale, and lead to new constructions.

In iron shipbuilding an immense field is opening before us. Our wooden walls have to all appearance seen their last days; and as one of the early pioneers in iron construction, as applied to shipbuilding, I am highly gratified to witness a change of opinion that augurs well for the security of the liberties of the country. From the commencement of iron shipbuilding in 1830 to the present time, there could be only one opinion among those best acquainted with the subject—namely, that iron must eventually supersede timber in every form of naval construction. The large ocean steamers, the Himalaya, the Persia, and the Great Eastern, abundantly show what can be done with iron; and we have only to look at the new system of casing ships with armour plates, to be convinced that we can no longer build wooden vessels of war with safety to our naval superiority and the best interests of the country. I give no opinion as to the details of the reconstruction of the navy—that is reserved for another place—but I may state that I am fully persuaded that the whole of our ships of war must be rebuilt of iron, and defended with iron armour calculated to resist projectiles of the heaviest description at high velocities. In the early stages of iron shipbuilding, I believe I was the first to show, by a long series of experiments, the superiority of wrought-iron over every other description of material in security and strength, when judiciously applied in the construction of ships of every class. Other considerations, however, affect the question of vessels of war; and although numerous experiments were made, yet none of the targets were on a scale sufficient to resist more than a 6-pounder shot. It was reserved for our scientific neighbours, the French, to introduce thick iron plates as a defensive armour for ships. The success which has attended the adoption of this new system of defence affords the prospect of invulnerable ships of war, and hence the desire of the Government to remodel the navy on an entirely new principle of construction, in order that it may retain its superiority as the great bulwark of the nation. A committee has been appointed by the War-office and the Admiralty, for the purpose of carrying out a scientific investigation of the subject, so as to determine—first, the best description of material to resist projectiles; secondly, the best method of fastening and applying that material to the sides of ships and land fortifications; and, lastly, the thickness necessary to resist the different descriptions of ordnance. It is asserted, probably with truth, that whatever thickness of plates is adopted for casing ships, guns will be constructed capable of destroying them. But their destruction will even then be a work of time, and I believe, from what I have seen in recent experiments, that with proper armour it will require, not only the most powerful ordnance, but also a great concentration of fire, before fracture will ensue. If this be the case, a well-constructed iron ship, covered with sound plates of the proper thickness, firmly attached to its sides, will for a considerable time resist the heaviest guns which can be brought to bear against it, and be pratically shot-proof. But our present means are inadequate for the production of large masses of iron, and we may trust that, with new tools and machinery, and the skill, energy, and perseverance of our manufacturers, every difficulty will be overcome, and armour plates produced which will resist the heaviest existing ordnance. The rifling of heavy ordnance, the introduction of wrought-iron, and the new principle of construction with strained hoops, have given to all countries the means of increasing enormously the destructive power of their ordnance. One of the results of this introduction of wrought-iron, and correct principles of manufacture, is the reduction of the weight of the new guns to about two-thirds the weight of the older cast-iron ordnance. Hence follows the facility with which guns of much greater power can be worked, while the range and precision of fire are at the same time increased. But these improvements cannot be confined to ourselves. Other nations are increasing the power and range of their artillery in a similar degree, and the energies of the nation must, therefore, be directed to maintain the superiority of our navy in armour as well as in armament.

We have already seen a new era in the history of the construction of bridges, resulting from the use of iron; and we have only to examine those of the tubular form over the Conway and Menai Straits to be convinced of the durability, strength, and lightness of tubular constructions applied to the support of railways or common roads in spans which ten years ago were considered beyond the reach of human skill. When it is considered that stone bridges do not exceed 150 feet in span, nor cast-iron bridges 250 feet, we can estimate the progress which has been made in crossing rivers 400 or 500 feet in width without any support at the middle of the stream. Even spans greatly in excess of this may be bridged over with safety, provided we do not exceed 1800 to 2000 feet, when the structure would be destroyed by its own weight.

It is to the exactitude and accuracy of our machine-tools that our machinery of the present time owes its smoothness of motion and certainty of action. When I first entered this city the whole of the machinery was executed by hand. There were neither planing, slotting, nor shaping machines, and, with the exception of very imperfect lathes and a few drills, the preparatory operations of construction were effected entirely by the hands of the workman. Now everything is done by machine tools, with a degree of accuracy which the unaided hand could never accomplish. The automaton, or self-acting machine tool, has within itself an almost creative power; in fact, so great are its powers of adaptation, that there is no operation of the human hand that it does not imitate. For many of these improvements the country is indebted to the genius of our townsmen, Mr. Richard Roberts and Mr. Joseph Whitworth. The importance of these constructive machines is, moreover, strikingly exemplified in the Government works at Woolwich and Enfield-lock, chiefly arranged under the direction of Mr. Anderson, the present Inspector of Machinery, to whose skill and ingenuity the country is greatly indebted for the efficient state of those great arsenals.

Among the changes which have largely contributed to the comfort and enjoyment of life, are the improvements in the sanitary condition of towns. These belong probably to the province of social rather than mechanical science; but I cannot omit to notice some of the great works that have of late years been constructed for the supply of water and for the drainage of towns. In former days 10 gallons of water to each person per day was considered an ample allowance. Now, 30 gallons is much nearer the rate of consumption. I may instance the water-works of this city and of Liverpool, each of which yield a supply of from 20 to 30 gallons of water to each inhabitant. In the former case the water is collected from the Cheshire and Derbyshire hills, and after being conveyed in tunnels and aqueducts a distance of 10 miles to a reservoir, where it is strained and purified, it is ultimately taken a further distance of 8 miles in pipes, in a perfectly pure state, ready for distribution. The greatest undertaking of this kind, however, yet accomplished is that by which the pure waters of Loch Katrine are distributed to the city of Glasgow. This work, recently completed by Mr. Bateman, who was also the constructor of the water-works of this city, is of the most gigantic character, the water being conveyed in a covered tunnel a distance of 27 miles, through an almost impassable country, to the service reservoir, about 8 miles from Glasgow. By this means 40 million gallons of water per day are conveyed through the hills which flank Ben Lomond, and, after traversing the sides of Loch Chon and Loch Aird, are finally discharged into the Mugdock Basin, where the water is impounded for distribution. We may reasonably look forward to an extension of similar benefits to the metropolis, by the same engineer, whose energies are now directed to an examination of the pure fountains of Wales, from whence the future supply of water to the great city is likely to be derived. A work of so gigantic a character may be looked upon as problematical, but when it is known that six or seven millions of money would be sufficient for its execution, I can see no reason why an undertaking of so much consequence to the health of London should not ultimately be accomplished.

In leaving this subject, I cannot refrain from an expression of deep regret at the loss which science has sustained through the death of one of our vice-presidents, the late Professor Hodgkinson. For a long series of years he and I worked together in the same field of scientific research, and our labours are recorded in the Transactions of this and other associations. To Mr. Hodgkinson we owe the determination of the true form of cast-iron beams, or section of greatest strength; the law of the elasticity of iron under tensile and compressive forces; and the laws of resistance of columns to compression. I look back to the days of our joint labour with unalloyed pleasure and satisfaction. I regret to say that another of our vice-presidents, my friend Mr. Joseph Whitworth, is unable to be present with us through serious, but I hope not dangerous illness. To Mr. Whitworth mechanical science is indebted for some of the most accurate and delicate pieces of mechanism ever executed; and the exactitude he has introduced into every mechanical operation will long continue to be the admiration of posterity. His system of screw threads and gauges is now in general use throughout Europe. We owe to him a machine for measuring with accuracy to the millionth of an inch, employed in the production of standard gauges; and his laborious and interesting experiments on rifled ordnance have resulted in the production of a rifled small-arm and gun which have never been surpassed for range and precision of fire. It is with pain that I have to refer to the cause which deprives me of his presence and suppport at this meeting.

A brief allusion must be made to that marvellous discovery which has given to the present generation the power to turn the spark of heaven to the uses of speech; to transmit along the slender wire for a thousand miles a current of electricity that renders intelligible words and thoughts. This wonderful discovery, so familiar to us, and so useful in our communications to every part of the globe, we owe to Wheatstone, Thomson, De la Rive, and others. In land telegraphy the chief difficulties have been surmounted, but in submarine telegraphy much remains to be accomplished. Failures have been repeated so often as to call for a commission on the part of the Government to inquire into the causes, and the best means of overcoming the difficulties which present themselves. I had the honour to serve on that commission, and I believe that from the report, and mass of evidence and experimental research accumulated, the public will derive very important information. It is well known that three conditions are essential to success in the construction of ocean telegraphs—perfect insulation, external protection, and appropriate apparatus for laying the cable safely on its ocean bed. That we are far from having succeeded in fulfilling these conditions is evident from the fact, that out of 12,000 miles of submarine cable which have been laid since 1851, only 3000 miles are actually in working order; so that three-fourths may be considered as a failure and loss to the country. The insulators hitherto employed are subject to deterioration from mechanical violence, from chemical decomposition or decay, and from the absorption of water; but the last circumstance does not seem to influence seriously the durability of cables. Electrically, india-rubber possesses high advantages, and, next to it, Wray's compound and pure gutta-percha far surpass the commercial gutta-percha hitherto employed; but it remains to be seen whether the mechanical and commercial difficulties in the employment of these new materials can be successfully overcome. The external protecting covering is still a subject of anxious consideration. The objections to iron wire are its weight and liability to corrosion. Hemp has been substituted, but at present with no satisfactory result. All these difficulties, together with those connected with the coiling and paying out of the cable, will no doubt yield to careful experiment and the employment of proper instruments in its construction, and its final deposit on the bed of the ocean. Irrespective of inland and international telegraphy, a new system of communication has been introduced by Professor Wheatstone, whereby intercourse can be carried on between private families, public offices, and the works of merchants and manufacturers. This application of electric currents cannot be too highly appreciated, from its great efficiency and comparatively small expense. To show to what an extent this improvement has been carried, I may state that 1000 wires, in a perfect state of insulation, may be formed into a rope not exceeding half-an-inch in diameter.

I must not sit down without directing attention to a subject of deep importance to all classes—namely, the amount of protection inventors should receive from the laws of the country. It is the opinion of many that patent laws are injurious rather than beneficial, and that no legal protection of this kind ought to be granted; in fact, that a free-trade in inventions, as in everything else, should be established. I confess I am not of that opinion. Doubtless there are abuses in the working of the patent law as it at present exists, and protection is often granted to pirates and impostors, to the detriment of real inventors. This, however, does not contravene the principle of protection, but rather calls for reform and amendment. It is asserted by those who have done the least to benefit their country by inventions, that a monopoly is injurious, and that if the patent laws are defended, it should be, not on the ground of their benefit to the inventor, but on that of their utility to the nation. I believe this to be a dangerous doctrine, and I hope it will never be acted upon. I cannot see the right of the nation to appropriate the labours of a lifetime, without awarding any remuneration. The nation, in this case, receives a benefit; and assuredly the labourer is worthy of his hire. I am no friend of monopoly, but neither am I a friend of injustice; and I think that, before the public are benefited by an invention, the inventor should be rewarded either by a 14 years' monopoly, or in some other way. Our patent laws are defective, so far as they protect pretended inventions; but they are essential to the best interests of the State in stimulating the exertions of a class of eminent men, such as Arkwright, Watt, and Crompton, whose inventions have entailed upon all countries invaluable benefits, and have done honour to the human race. To this association is committed the task of correcting the abuses of the present system, and establishing such legal provisions as shall deal out equal justice to the inventor and the nation at large.

I must not forget that we owe very much to an entirely new and most attractive method of diffusing knowledge, admirably exemplified in the Great Exhibtion of 1851, and its successors in France, Ireland, and America. Most of us remember the gems of art which were accumulated in this city during the summer of 1857, and the wonderful results they produced on all classes of the community. The improvement of taste, and the increase of practical knowledge which followed these exhibitions, have been deeply felt; and hence the prospects which are now opening before us in regard to the Exhibition of next year cannot be too highly appreciated. That Exhibition will embrace the whole circle of the sciences, and is likely to elevate the general culture of the public to a higher standard than we have ever before attained. There will be unfolded almost every known production of art, every ingenious contrivance in machinery, and the results of discoveries in science from the earliest period. The fine arts, which constituted no part of the Exhibition of 1851, and which were only partially represented at Paris and Dublin, will be illustrated by new creations from the most distinguished masters of the modern school. Looking forwards, I venture to hope for a great success and a further development of the principle advocated by this association—the union of science and art.

In conclusion, my apologies are due to you for the length of this address, and I thank you sincerely for the patient attention with which you have listened to the remarks I have had the honour to lay before you. As the President of the British Association, I feel that, far beyond the consideration of merely personal qualifications, my election was intended as a compliment to practical science, and to this great and influential metropolis of manufacture, where those who cultivate the theory of science may witness, on its grandest scale, its application to the industrial arts. As a citizen of Manchester I venture to assure the association that its intentions are appreciated; and to its members, as well as to the strangers who have been attracted here by this meeting, I offer a most cordial welcome.

MECHANICAL SECTION.

President.—J. F. Bateman, C.E., F.R.S.
Vice Presidents.—Sir W. G. Armstrong, Thomas Fairbairn, Capt. Douglas Galton, the Mayor of Manchester, Sir John Rennie, Rev. Dr. Robinson, J. Scott Russell, Thomas Webster, Rev. Prof. Willis.
Secretaries.—P. Le Neve Foster, John Robinson, Henry Wright.
Committee.—James Abernethy, J. G. Appold, Theo. Aston, Charles Atherton, George Bayley, Admiral Sir E. Belcher, Charles F. Beyer, Capt. Blakeley, J. C. Dennis, Capt. Dyer, Wm. Fairbairn, Jas. Fenton, Lloyd Foster, Thos. B. Boster, B. Fothergill, J. Gilbert, Andrew Henderson, John Hetherington, John Hick, John Hopkinson, W. B Johnson, A. J. Macrory, sen.; James E. McConnell, James R. Napier, James Oldham, John Platt, John Ramsbottom, E. J. Reed, sec. Inst. N.A.; Richard Roberts, Norman Scott Russell, C. W. Siemens, James Smith, W. Smith, Bindon B. Stoney, Charles Vignolles, Joseph Whitworth, Bennett Woodcroft.

The President, Mr. BATEMAN, on opening the proceedings of the section, delivered an introductory address, in the course of which he said—

It is now nineteen years since I had the privilege of becoming a member of this association, and of acting as one of the secretaries of this section at its former meeting in Manchester. During that period there was a time of apathy, when for some years it seemed doubtful whether the section could keep itself alive, and when I believe the propriety of putting an end to it was seriously debated. Since the meeting at Hull, however, when our excellent president presided over the interests of this section, it has pursued a more vigorous career, and as there is no section of which the practical importance can be more fully admitted, so I trust the exertions of its supporters will impart such interest to its proceedings as will render it as attractive to the real promoters of science as any section of the association, and as useful in its results. In Manchester especially this section should be well supported, for in this district have been or have resided some of the most distinguished projectors and inventors of the age—men whose ingenuity and labours have conferred incalculable benefit upon the world: such men as the Duke of Bridgwater, Sir Richard Arkwright, and Samuel Crompton, in days not long gone by, and whose places have been well filled by the inventors and mechanics of our own time.

Amongst the questions which have recently attracted popular attention, and which are specially deserving of the consideration of the mechanical men of the day, are the improvements which are taking place in the construction of artillery, and in the antagonistic work of protecting the vessels of our navy from the terrible destruction to which they are exposed by the superior power and longer range of the guns which can now be brought to bear against them. . . .

The anxious attention of those most interested in the management of railways was, during the late very severe winter, when the thermometer fell in some places 10° or 12° below zero, unexpectedly directed to the sudden and numerous fractures in the tires of the wheels of the carriages and engines. Indeed, for some weeks, travelling by railway was exceedingly unsafe, and the speed of the trains had to be generally and materially reduced. The cause of these fractures, and the best mode of preventing similar occurrences in severe cold, are matters of public importance, and fit subjects for notice and discussion in this section. But serious as were the dangers resulting from the intense cold of last winter, they are as nothing to those which appear to attend railway travelling by the excursion trains of the summer, for within the last few days we have been horrified by the accounts of two of the most disastrous accidents which have occurred in this country. The prevention of railway accidents is a fruitful subject of discussion, and one to which this section may very usefully devote a portion of its time and attention.

Another subject, which has recently attracted attention by the terrible and disastrous conflagration in Tooley-street, London, is the extinction of fire. The powers which now exist for this purpose, with the methods that are adopted, would form useful topics for consideration, and such notices as will illustrate the most approved methods of prevention—whether by the adoption of plans of fire-proof construction, or by the judicious application of water—could not fail to be both interesting and instructive. In a report written in 1844, by Mr. Samuel Holme, on the prevention of fire in Liverpool, he gave an estimate of the loss which had been occasioned by fires in half a century, amounting to the sum of £1,250,000, and the loss of upwards of sixty lives. The frequent recurrence of fire was sufficient to give Liverpool an unenviable notoriety; but the single fire in Tooley-street, which occurred last June, nearly doubled the total loss which had occurred in Liverpool during a period of fifty years. Manchester has fortunately been comparatively exempt from calamities of this nature. I find from the returns prepared by Mr. Rose, the superintendent of the fire brigade, that from 1848 to 1860 inclusive, the total amount of property destroyed has been £854,373, and the total amount of property saved has been £5,900,364, being an average salvage of £453,874, and an average destruction of property amounting to £65,721. There are peculiarities in the means adopted at Manchester for the prevention of fires, which are deserving of attention. Probably this subject will be alluded to in the course of the meeting; but, as having been responsible for the arrangements that were adopted when the whole piping of the city was re-organised and extended, on the introduction of the new supply from Longdendale, I may perhaps be allowed to say a few words on the subject. We had an ample supply of water, and considerable pressure, varying from 100 to 200 feet in the centre of the city and in those parts in which the most valuable descriptions of property were generally to be found. With these advantages, it was my object to get rid of the old, clumsy, wooden contrivance called a "fire-plug," which was a disgrace to the mechanical skill of the age, and to do away as far as possible with the use of fire-engines. This we have to a great extent been enabled to do, both in Manchester and elsewhere. In those parts of the city in which protection against fire was most important, the dimensions and arrangements of the pipes were determined with special reference to these circumstances. In place of the old wood plug, a simple fire-cock, by which almost instantaneous communication could be made with the water in the pipe, and to which a hose and jet could be attached, was adopted, and the fire-engines were rather used as carriages or omnibuses for the conveyance of the firemen and their implements, than for actual use at a fire. Nearly every valuable block of building in Manchester is commanded by at least a dozen fire-cocks within 100 yards. As an illustration of the advantage derived, I may quote from a report on the re-arrangement of the piping in the city of Glasgow, in which the same principles have been adopted. "As an illustration of this, I may mention two fires that have occurred in Manchester, one immediately before the introduction of the fresh supply of water there and the adoption of the improved fire-cock, and the other after the new system had been perfected. The first was a large warehouse in Piccadilly, the property of Messrs. Wood and Westhead, which was burned to the ground with all its contents, the damage done being about £90,000. There were nine fire-engines on the ground at work, and one idle, and, in addition, four jets from fire-cocks of an old construction. Upwards of 500 persons were employed to work the fire-engines. The other was the warehouse of Messrs. Alexander Henry and Co., in the immediate neighbourhood of the first. Mr. Rose, the superintendent of the fire-brigade, informs me that there were goods in the warehouse of the value of £145,000, and that when he arrived at the building the fire was blazing out of eighteen windowss. In less than twenty minutes eleven jets were at work from fire-cocks in the streets—not more than fifty men were employed, and the damage done was only £35,000: £110,000 were saved." The great object to be arrived at is the immediate application of a sufficient quantity of water at the commencement of a fire; when it has once attained a powerful ascendancy scarcely any water can extinguish it, and all that can be done by the firemen is to prevent its extending to adjoining property. It should also be borne in mind that water cannot be thrown with effect either by the pressure of gravitation or by the force-pump of the fire-engine beyond a limited height, which is practically under 100 feet.

Abstract of an Investigation on the Resistance of Ships. By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS. Lond. & Edin.

This paper is a very brief abstract of the results of an investigation of the laws of the resistance of ships, founded originally on experimental data supplied to the author by Mr. James R. Napier, in 1857, and first applied to practice in order to fix beforehand the engine-power required for a ship, in 1858. To state all the mathematical details of the investigation would occupy much more time than can reasonably be allotted to one paper at a meeting of the British Association; the present communication therefore will be limited to a general view of the nature of the theory adopted, a statement of the practical rules to which it leads for computing the power required to propel a given ship at a given speed, an abstract of some comparisons between the results of those rules and those of experiment, a statement of the limitations to which the application of the theory is subject, and some general conclusions deduced from it.

I. GENERAL VIEW OF THE THEORY.

The importance of friction as one of the elements of the resistance of water to the motion of a ship has long been recognised. Colonel Beaufoy made many experiments on models, expressly to ascertain its amount. Mr. Hawksley some years ago proposed a formula for the resistance of vessels, consisting of three terms; of which two—representing the effect of pressure on the bow and stern—depend on the area of midship section, and the figures of the bow and stern; while the third—representing the effect of friction—is proportional to the wetted surface of the ship. Mr. Bourne, in his work on the screw propeller, mentions friction as an element of the resistance of ships, which must depend on the girth rather than on the midship section.

It is to be remarked, however, that in all previous investigations as to the friction of ships in moving through the water, the velocity of the sliding motion of the particles of water over the ship's bottom has been treated as being sensibly equal to the forward velocity of the ship, and sensibly the same at every point of the ship's bottom; whereas, in fact, it must be different at different points of the ship's bottom,—at some points less than the ship's speed, at other points greater; and, on an average, greater than the ship's speed in a proportion which is greater the more bluff the figure of the ship. No definite results are to be expected from any comparison of experiment with a theory which does not take account of those variations.

It is further to be remarked that the excess of the pressure of the water against the bow of a ship above its pressure against the stern is only an indirect effect of friction; for, were it not for the loss of motive energy which takes place through friction, the particles of water would close behind the vessel with such speed as to exert a forward pressure exactly equal to the backward pressure of the particles of water which are forced aside at the bow.

The author was induced by these considerations to investigate the theory of the friction of the water against the bottom of a ship, taking into account the various velocities of sliding at various points, as affected by the positions of those points and by the figure of the ship; and making only the following assumption—that the agitation in the water caused by its friction on the ship's bottom extends only to a layer of water which is very thin as compared with the dimensions of the ship. This assumption enables the ratio which the velocity of sliding at any point bears to the speed of the ship, to be expressed as a mathematical function of the position of the point, and of the ship's figure, by the aid of the general equations of fluid motion; and from that function is deduced a certain integral, which expresses the work performed in overcoming friction over the whole wetted surface of the ship, while the ship advances through a given distance, such as one foot; and to that quantity of work the force required to drive the ship against the friction of the water is proportional. The mathematical investigation is tedious and voluminous, and is reserved for a detailed paper. The exact expressions arrived at were very complex, but were easily reduced to more simple expressions, giving an approximation sufficient for the purpose in view.

Upon comparing the formula thus obtained with the indicated power of actual ships moving at known speeds, it was found that *the whole* power required to propel the ships could be accounted for by friction alone, leaving none to be accounted for by any excess of pressure at the bow above that at the stern, except such excess as is indirectly caused by the friction, and virtually comprehended in the expression for the power required to overcome friction.

II. PRACTICAL RULE FOR THE POWER REQUIRED TO PROPEL A SHIP, WITH TROCHOIDAL, OR NEARLY TROCHOIDAL, WATER-LINES.

The first rule obtained in a form sufficiently simple for practical use was the following:—"The resistance of a sharp-ended ship exceeds the resistance of a current of water of the same velocity in a channel of the same length and mean girth, by a quantity proportional to the square of the greatest breadth divided by the square of the length of the bow and stern." The *mean girth* is found by taking the mean of the girths, as measured on the body-plan of the vessel, of the immersed parts of a series of equidistant frames or cross-sections. The algebraical expression of this rule is as follows:—

$$R = \frac{fwv^2}{2g} . LG\left(1 + \frac{\pi^2 B^2}{L_1^2}\right) \quad \dots \quad \dots \quad (1)$$

in which R denotes the resistance of the vessel; L, her total length at the water-line, in feet; L_1 the length of her bow and stern together, in feet; B, her greatest breadth, in feet; G, her *mean girth* under water; $\pi^2 = 9{\cdot}87$; *v*, the ship's speed, in feet per second; *g*, the acceleration produced by gravity in a second, or 32·2 feet; *w*, the weight of a cubic foot of salt-water, or about 64 lb.; *f*, a coefficient of friction, whose value for iron ships in a clean state, as on their trial trips, is about ·0036, or nearly the same with the coefficient of friction of water at high speeds in cast-iron pipes.

The expression for the indicated horse-power of the engine, deduced from the preceding formula, is as follows:—

$$\text{I. H. P.} = \frac{k\,R\,v}{550} = \frac{kfwv^3}{550 \times 2g} . LG\left(1 + \frac{\pi^2 B^2}{L_1^2}\right) \quad \dots \quad (2)$$

in which *k* is a coefficient expressing the ratio of the gross indicated power to the effective power, allowing for the friction of the machinery and slip of the propeller. Its average value is about 1·6; so that $kf =$ about ·00576 on an average for ships in a clean state.

But the most convenient formula for practice is one in which the velocity V is given in nautical miles per hour, and is as follows:—

$$\text{I. H. P.} = \frac{V^3}{C} . LG\left(1 + \frac{\pi^2 B^2}{L_1^2}\right) \quad \dots \quad \dots \quad (3)$$

C being a divisor, whose value is

$$C = \frac{550 \times 2g}{4{\cdot}8064 \times kfw} = \frac{115}{kf} \text{ nearly} \quad \dots \quad \dots \quad (4)$$

or if $kf = {\cdot}00576$, $C = 20{,}000$ nearly.

This rule, with a coefficient of resistance deduced from some experiments on previously existing vessels, was applied in 1858 to the computation of the engine-power required to propel a vessel then in course of construction (the Admiral); and at the trial trip of that vessel on the 11th of June, 1858 (the particulars of which, together with a copy of her body-plan, have been communicated to the Committee of the British Association on Steam-ship Performance*), the actual engine-power was found to differ from the theoretically computed engine-power by less than one-fiftieth part of its amount, the computed power being 758, and the actual power 744; and that notwithstanding that the Admiral differed materially in her proportions from the vessels from whose performance the coefficient of resistance had been deduced. The rule was afterwards applied with equal success to fix the engine-power of other vessels built by Mr. J. R. Napier.

III. MORE COMPREHENSIVE RULE FOR THE POWER REQUIRED TO PROPEL A SHIP.

The rule in the form already given was deduced from a mathematical investigation based upon a trochoidal form of water-line; and therefore, although it could be applied with approximate accuracy to vessels approaching to that type, some doubt and difficulty arose in applying it to those which deviated widely from the trochoidal form. To obviate that difficulty, the rule was put into another form, which, while it was identical in its results with the original form for trochoidal water-lines, was more readily applicable to water-lines of other shapes. The alteration consists in this, that instead of "a quantity proportional to the square of the greatest breadth divided by the square of the length of the bow and stern," there is to be substituted "a quantity proportional to the square of the chord of the mean angle of entrance of the water-lines;" it being understood that the angle of entrance of a given water-line is the angle between its two tangents at opposite sides of the bow, at the points where it is most inclined to the keel; and that the mean value of that angle is to be taken for a series of equidistant water-lines or horizontal sections of the vessel. The algebraical expression for the resistance now takes the following form—

---

* See Report of that Committee to the Aberdeen meeting of the Association, 1859.

$$R = \frac{fwv^2}{2g} \,.\, LG\left(1 + 4\sin^2\frac{\theta}{2}\right) \ \ldots \qquad \ldots \ (5)$$

in which the symbols are the same with those already explained, except θ, which denotes the mean angle of entrance, as already defined. In what follows, for brevity's sake, the quantity $4\sin^2\frac{\theta}{2}$ is denoted by b^2. The two expressions for the engine-power become respectively

$$\text{I. H. P.} = \frac{kfwv^3}{550 \times 2g} \,.\, LG(1+b^2) \ \ldots \qquad \ldots \ (6)$$

$$= \frac{V^3 .\, LG\,(1+b^2)}{C} \ldots \qquad \ldots \qquad \ldots \ (7)$$

The processes involved in this rule may be represented to the mind as follows:—

1. Multiply together the length (L) of the vessel at the surface of the water, and the mean girth (G) of the immersed parts of the cross-sections or frames; this gives the area of the internal surface of a channel or tube of the same length and mean girth with the vessel (LG).

2. Increase that area in the ratio of unity *plus* the square of the chord of the mean angle of entrance $(1+b^2)$, to unity; this increase is an approximate value of the allowance indicated by theory for the obliquity of the surface of the vessel, and for the excess of the speed of sliding of the particles of water over various portions of it, above the speed of the vessel. The result of this process [LG $(1+b^2)$] may be called the "AUGMENTED SURFACE."

3. Compute the height from which a heavy body must fall to acquire the speed of the ship, $\left(\frac{v2}{2g}\right)$; multiply that height by a *coefficient of friction* (f) deduced from experiment; conceive a layer of water of the thickness resulting from the last multiplication to be spread over an area equal to the "augmented surface;"—the weight of that layer will be the resistance of the vessel at the given speed (R).

4. Multiply that resistance by the speed of the vessel in feet per second, and by a factor (k) ascertained by experiment, to allow for the loss of power by slip and by the friction of the engine and propeller; the result will be the power or mechanical energy expended in a second; which, divided by 550, gives the indicated horse-power.

Although in most cases the coefficient of friction (f) and factor for loss of power (k) cannot be separately ascertained, their product (kf) can always be ascertained by experiment, and this may be called the "gross coefficient of resistance."

5. The more convenient rule for finding the required indicated horse-power may be thus expressed: multiply the "augmented surface" by the cube of the speed in knots, and divide by a divisor which is found by experiment $\left(C = \frac{115}{kf}\right)$.

IV. COMPARISON OF THE THEORY WITH EXPERIMENT.

In applying this theory to experimental data, the proper course is to compute from those data the value in each case either of the gross coefficient of resistance (kf), or of the divisor (C) which is inversely proportional to that coefficient; and should those values present such variations only as can be accounted for by ordinary variations in the efficiency of engines and propellers, and in the condition of the vessel's bottom, the inference is in favour of the soundness of the theory. It is necessary in every case to have access to the plans of the vessel, and hence complete sets of data are less abundant than could be wished.

The formulæ to be employed are as follows:—For the divisor,

$$C = \frac{V^3 .\, LG\,(1+b^2)}{\text{I. H. P.}} \ldots \qquad \ldots \qquad \ldots \ (8)$$

for the gross coefficient of resistance,

$$kf = \frac{115}{C} \qquad \ldots \qquad \ldots \qquad \ldots \ (9)$$

The following table gives nine examples of such calculations. Three of them are founded on experiments made by Mr. J. R. Napier and the author; four on published data relative to government vessels; and two on published reports of the trial trips of vessels belonging to the Peninsular and Oriental Steam Navigation Company. The breadth, mean draught of water, midship section, and displacement are given in each case, to show the variety of forms and sizes to which the calculations relate. The displacement ranges from 140 to 3000 tons; the proportion of length to breadth, from 5½ to 10; the proportion of breadth to draught of water, from 2¼ to 4¼. The final results show the divisor as ranging from 19,210 to 20,864, and the gross coefficient of resistance from ·00599 to ·00551.

Example.	Length. L	Breadth.	Mean Draught.	Midship Section.	Displacement.	Mean girth G	LG	$1+b^2$	* Augmented Surface. $LG(1+b^2)$	Speed in knots. V	I.H.P.	Divisor. C	Coefficient of Gross Resistance kf
	Feet.	Feet.	Feet.	Sq. feet.	Tons.	Feet.	Sq. feet.		Sq. feet.				
1. Vulcan (paddle) ...	160	16	4·5	56	140	14·75	2360	1·1	2596	14·5	412	19,210	·00599
2. Black Swan, now Gange (screw) ...	244	36·5	13·8	385	1670	40	9760	1·2	11,712	12	970	20,864	·00551
3. Admiral (paddle) ...	210	32	7·5	214	820	31·5	6615	1·36	9000	11·9	744	20,385	·00565
4. Rattler (screw) ...	178	33	11·25	274	870	32·5	5785	1·4	8099	10·07	428	19,360	·00593
5. Ditto	...	...	13·5	330	1078	37·5	6675	1·4	9345	9·64	437	19,370	·00593
6. Fairy (screw) ...	140	21·1	4·83	71·5	168	19·0	2660	1·2	3192	13·33	364	20,770	·00554
7. Ditto	...	...	5·83	82	196	21·5	3010	1·23	3702	11·9	321	19,435	·00592
8. Ceylon (screw) ...	290	41	18·5	649	3000 (nearly)	52·4	15,196	1·16	17,625	13·34	2054	20,374	·00565
9. Nubia (screw) ...	280	39·5	17·25	515	2100 (nearly)	48·2	13,496	1·16	15,655	12·15	1422	19,725	·00583

V. LIMITATIONS TO THE THEORY.

The theory stated in this paper is not applicable to vessels which are so bluff at the bow and stern as to push before them or drag behind them a mass of water full of whirling eddies; for in such vessels the assumption already stated, that the water agitated by friction is a very thin layer, is not fulfilled.

Neither is the theory applicable to a vessel which raises a wave that buries a considerable proportion of her bows. This does not occur in well-shaped vessels of the sizes to which the experiments already quoted relate; but it may occur in models, as experiments made by Mr. James R. Napier and the author have shown. Small wooden models of vessels were made, of very various proportions, the proportion of length to breadth ranging from 5 to 10. The *proportionate* resistances of those models when dragged in pairs at equal speeds were tested by means of suitable apparatus; and it was found, that when the speed was so small as not to raise a wave exceeding the ordinary proportion of the height of the wave to the dimensions of the vessel in large ships (say, from one-tenth to one-twentieth of the draught of water), the results of the experiments exactly agreed with the theory; but when the speed was increased until the wave buried from one-half to the whole of the bows of the models, the resistance of the broader model was increased in a greater proportion than that of the narrower.

From the results of these experiments it follows, that in order that conclusions drawn from experiments on models may be applicable to actual ships, care should be taken not to move the model at a speed which raises a wave exceeding in proportionate height the wave raised by the larger vessel; and that such may be the case, the velocities of the model and of the ship should be proportional to the square roots of their linear dimensions. For example, the models already mentioned were of about one-hundredth part of the linear dimensions of the vessels that they were intended to represent, and when dragged at one-tenth of the speed of those vessels, or less, their resistance followed the same laws, but not otherwise. This conclusion is common to the theory of the present paper, and to Mr. Scott Russell's wave theory.

The effect of such waves as have been here referred to on the resistance might be taken into account by means of a supplementary theory, provided a sufficient number of experiments had been made on the large scale to determine the necessary data; but in the experiments on the large scale quoted in this paper, the resistance due to the wave at the bow seems to have been insensible, or to have been balanced or nearly balanced by the pressure of the wave at the stern. This balanced action is to be expected in vessels whose lengths, as prescribed by Mr. Scott Russell, are equal, or nearly equal, to the lengths of waves travelling with the same speed.

VI. DEDUCTIONS FROM THE THEORY.

The approximate expression for the resistance may be divided into two terms, one of which is increased and the other diminished, by increase of length. For a vessel of a given size and type, there is some proportion of length to breadth which makes the resistance a minimum. To determine that proportion exactly by the method of maxima and minima would be a process of extreme complexity and difficulty; but from a series of approximate calculations made by way of trial, it would appear to be not very far from that of 7 to 1: a conclusion in accordance with that which some authorities on shipbuilding have deduced from practical experience. It appears further, that of two vessels which deviate equally in opposite directions from the best proportion, the longer has less resistance than the shorter: this conclusion also agrees with practical experience.

If, as the comparison of the theory with experiment seems to show, the resistance of a vessel is proportional to what has been called the "augmented surface," it is the area so designated, and not the midship section, which should regulate the areas of paddles and screws.

The results of the investigation described in this paper tend to prove that friction constitutes the most important part, if not the whole, of the resistance of ships that are well-formed for speed; and that its amount can be deduced with great precision from the figure of the ship by the aid of proper mathematical processes. On this, as well as on other accounts, it is to be desired that the data which are collected by the Committee of the British Association on Steam-ship Performance should be accompanied as far as possible by drawings of the ships' lines: at all events, by the "body plans," from which the forms of water-lines can easily be constructed when the distances between the frames are known.

APPENDIX.

(Added since the meeting of the Association.)

Comparison between the published Plans of two Sailing Yachts, the Themis (formerly Titania) and the America.

	THEMIS.	AMERICA.
Tonnage, builders' old measure	99	210
Area of horizontal section at load water-line in sq. feet	1180	1280
Greatest breadth at load water-line in feet	19	22
L; feet (length at load water-line, including stem and rudder	84	92
G; feet (mean girth)	27	25
$1+b^2$	1·13	1·11
"Augmented surface," $LG(1+b^2)$; square feet ...	2563	2556
Midship section; square feet	90	99

The tonnage by builders' old measurement is stated, because it is usual to consider it as an indication of the capacity of yachts to carry sail. In the present instance it greatly exaggerates the difference between the vessels in that respect; for the smallness of the tonnage of the Themis is caused by the great rake of her sternpost, from the foot of which the length for tonnage, b.o.m., is measured. Had she an upright sternpost, like the America, her tonnage, b.o.m., would be about 122.

The area of horizontal section at the load-water-line is given; because the capacity to carry sail, though not simply proportional to that quantity, is to a great extent dependent on it. The greatest breadth at the load-water-line is given for a similar reason.

From this comparison it appears, that while the capacity of the America to carry sail is considerably greater than that of the Themis, the "augmented surfaces" of the two vessels are sensibly equal (the difference of 7 square feet being within the limits of errors of measurement); so that the America, according to the theory, ought to be the more speedy vessel, notwithstanding her greater midship section: a result in accordance with that of the well-known trial of speed of those yachts.

The comparative greatness of the mean girth G in the Themis is caused mainly by the very hollow form of her cross-sections. If they were nearly triangular, like those of the America, the mean girths of those vessels would be nearly equal.

On Iron Construction, with Remarks on the Strength of Iron Columns and Arches. By F. W. SHEILDS, M. Inst. C. E.

It is almost needless to expatiate on the great and rapid development which the use of ironwork has received, within a few years preceding the present meeting. In bridge work, the ancient structures of masonry,—in roofing, the employment of wooden framing,—and in shipbuilding, the use of timber both in the naval and mercantile marine, are being gradually superseded by a material eminently possessed of the qualities of strength, durability, and cheapness, for engineering construction. Nor are these effects confined to England alone, for the employment of British iron for such purposes has now become well-nigh universal. In fact, it appears almost anomalous, that iron for a bridge or other construction, manufactured in this country and conveyed abroad at considerable cost, should supersede, with economy and advantage, in Australia, India, Russia, or Spain, the materials indigenous to the country and found abundantly on the spot; and this when iron is more costly in itself than the materials of wood and stone which it supersedes.

This apparent contradiction is explained by two causes—1st, that iron possesses, size for size, much greater strength than any other substance in general use; and, 2nd, that it possesses eminently the capacity of being manufactured in such variable shapes and sizes as the nature of the case may require;—so that sufficient material may be supplied in each part of the structure to meet the stress or strain upon that part, without any being wasted or lost to use.

Under these circumstances, an iron construction of many parts accurately proportioned for its purpose, should, when loaded to the point of fracture, have every part strained to the full extent of its resisting power. If some of its parts be increased in scantling beyond this proportion, such increase will add nothing to the strength of the structure as a whole, which is limited by the strength of its weakest part, and will only involve the addition of useless weight and expense to the construction. It follows therefore, that the designer of iron structures should possess, not only the workman's practical knowledge of the material with which he has to deal, but should be peculiarly acquainted with the scientific and mechanical principles by which the strains on each part are found, so as to enable him to apportion correctly the scantlings for those parts.

The object therefore of this paper is to call attention to the necessity for a greater diffusion amongst practical men dealing with ironwork, of a knowledge of the mode of calculating the strains upon the usual constructions to which iron is applied. Nor is economy the only consideration which urges the necessity for progress in this respect. In a framing, where the strains are transmitted from one portion to another throughout the structure, the insufficiency of one part may easily compromise the stability of the whole; and the element of safety enters largely into the consideration of the question in this view.

It will not be attempted in this paper to recapitulate the scientific principles in question, which the author of these remarks has recently ventured to lay briefly before the public. It is conceived, however, that it may be acceptable to state the conclusion to which experience has led him as to the practical amount of loading which may be laid upon iron columns and arches; the results of which he has not previously made public.

IRON COLUMNS.

The foregoing remarks have had reference to framed and other structures of comparatively complicated character, with strains varying both in nature and in amount: but in the simple construction now alluded to it is believed that practice affords the best guide. The author's professional engagements in the construction of the Crystal Palace at Sydenham, and other works, have given him much opportunity of ascertaining the amount of load which cast-iron columns will sustain with safety. In his practice accordingly the following rules are adopted as the basis of calculation of their strength—the columns being supposed of good construction, with flat ends, and with base plates at their bearings.

For hollow columns of 20 to 24 diameters in length, columns may be loaded with

If cast $\frac{3}{4}$ in. thick or upwards, 2 tons per sq. in. sectional area of column.
" $\frac{5}{8}$ " " $1\frac{3}{4}$ " " "
" $\frac{1}{2}$ " " $1\frac{1}{2}$ " " "
" $\frac{3}{8}$ " " $1\frac{1}{4}$ " " "

For columns of 25 to 30 diameters in length,

If $\frac{3}{4}$ inch thick or upwards ... ... $1\frac{3}{4}$ tons per square inch.
$\frac{5}{8}$ " " ... ... $1\frac{1}{2}$ " "
$\frac{1}{2}$ " " ... ... $1\frac{1}{4}$ " "
$\frac{3}{8}$ " " ... . 1 " "

The cause of the modifications of loading from varying thicknesses is, that thin and light columns are more liable to fracture from inequalities of casting and from accident, and should therefore be less loaded in proportion than those of greater thickness.

IRON ARCHES.

In the apportionment of iron to meet the strain or thrust of an arch, it is usual amongst engineers to allow about $2\frac{1}{2}$ tons of thrust or pressure to each sectional inch of cast-iron; and 4 tons of pressure to each sectional inch of wrought-iron. Independently of the compression of the arch, it is advisable in very flat arches to consider the flat central portion as a girder, and to give to its top and bottom such flanges as a simple beam of its length and depth would require. Thus, in an arch forming a curve of 300 feet radius, which the author had recently to design, the central portion of 70 feet was considered as an independent girder, and treated in this manner.

In bringing these brief remarks to a close, it may be stated as their object, to promote a general knowledge of ruling principles in a subject of ever-growing importance.

Patent Tribunals. By W. Spence.

The number of patents in force on the 1st of July last was about as follows:—

Under the Old Law		2,586
Under the New Law—		
Patents under 3 years old	5850	
Ditto over 3 years and under 7 years	3850	
Ditto over 7 years and under 14 years	400	
		10,100
		12,686

Thus, speaking in round numbers, it may be said there are 12,000 patents now in force; and the amount of property represented by this number of patents (which is continually increasing) is surely of sufficient value to entitle it to consideration. When therefore we turn to the existing tribunals for trying conflicting rights, and find that, according to the testimony of the judges themselves, they are most defective, it becomes a serious question for patentees to consider whether some remedy cannot be provided by which patent property may be rescued from its present state of insecurity. Undoubtedly there are inherent difficulties in settling patent questions, but this is no reason why obvious and acknowledged defects in the existing tribunals should be allowed to continue without any effort being made to remove them. The strong language used by the judges in condemnation of the ordinary mode of trying patent cases is also worthy of notice, as showing the impossibility of working the system satisfactorily.

I think the chief objection to the present system lies in the mode of initiating the trial by a scientific contest of professional witnesses. The adoption of this plan has naturally increased the artificial character of the pleadings, the uncertainty of the case to which the court has to apply the law, and the difficulty for the jury of disentangling the facts from the technical science. Mr. Grove, in an article in the *Jurist* in the early part of last year, alludes to this defect in the following terms:—

> "A plaintiff patentee has all at stake—an alleged infringer comparatively little: the former therefore is provided with an array of counsel and scientific witnesses, which gives him an immense advantage when subjects are discussed unknown to the majority of judges and jurymen. The case is shaped adroitly, and the minds of the jury are generally moulded into the groove laid down by the advocate for the plaintiff, without being at all conscious of it. The cases generally last so long, that in spite of every desire to do justice, weariness prevents proper attention to the defendant's case, all that is interesting in the scientific questions having been already exhausted; and ultimately the counsel for the plaintiff has a general reply."

Then, after mentioning the advantage to the plaintiff of an opening and reply by counsel, he adds—

> "On the other hand, as against the plaintiff, it not unfrequently happens that a patent for a valuable invention is upset by an unforeseen defect in the specification."

According to Mr. Grove, whose well-known ability and experience entitle his observations to attention, it would appear that the present mode of procedure enables a plaintiff, who has sufficient capital to devote to a trial, to gain a considerable advantage by extending his case, by the aid of an imposing array of counsel and scientific witnesses, to the point of producing weariness in the court and jury. This is one aspect of the case; but then another is that a plaintiff patentee has to choose between the course described and that of running a great risk of detriment to his patent right by an adverse verdict. It is the custom for defendants to organise an attack upon the plaintiff's patent with the same combined force of counsel and scientific witnesses; and the plaintiff therefore finds himself compelled to protect his patent at great expense, so as to cover every point of attack as far as he can foresee it. Besides, a plaintiff patentee has too frequently to encounter the combined force of a confederacy of defendants, whose common purse enables them to carry on the warfare with crushing effect. But there is no means of placing any effectual check on abuses of this kind: they are fostered by the present system. To use Mr Grove's words, "Great defects exist in the trial of patent cases, some of which are incident to other forms of litigation, but some are peculiar to patent cases."

Then, besides the defects referred to, there is the enormous sacrifice of time involved, first in getting up a case, and then in waiting to have it tried. This and the actual expense of a trial render it impossible for many patentees to protect their patents against infringement. So that, without prolonging any remarks on the defects in patent tribunals, it may be assumed that there is an absolute need of radical improvement in them, so as to give to patent property a reasonable amount of security; and we have seen that the amount of property at stake is so great as to render its adequate protection a matter of considerable social consequence.

In adverting to the remedy for the evils, I intend to examine Mr Grove's suggestion, and to point out in what respect I agree with him and in what I differ from him: then I shall offer some suggestions of my own. Mr. Grove says—

> "My idea is, to have a court for advising the Crown on the grant of letters patent, for fixing the term for which they should be granted, for trying patent causes, and for examining and reporting on applications for prolonging the monopoly. The idea of a special court for trying patent causes is not new, it has been frequently discussed, and viewed with favour by many members of the bar; it has been alluded to by judges from the bench, and has been not unfavourably regarded by patent agents, attorneys, and others conversant with patent cases. I would, however, give such a court jurisdiction beyond that of merely trying patent causes; I would transfer to it the functions exercised at present by the attorney and solicitor general, with enlarged powers, or rather with the intention that the court should exercise the powers now vested in the law officials of the Crown in a more judicial and less ministerial manner."

Mr. Grove's plan (as may be gathered from this and other portions of his article) consists of three branches of judicial labour. First, fixing the term for the patent. Second, trying patent causes. Third, reporting on applications for prolongation of the term of patent right. As to the first branch, I do not agree with Mr. Grove. He proposes that every application for a patent should in the first instance be referred to the new court, and that "the claims should be heard upon petition in open court, where any opponent should also be heard, and the merits of the invention thus discussed as far as they could be at such a stage." Instead of the provisional specification being as now a sealed document, it is proposed to make it public as soon as it is deposited; and instead of the patent being granted as now on mere application, at the entire risk of the applicant (unless it be opposed), it is proposed to give the court a discretion as to the granting of a patent at all, and in any case to fix the term of the patent right according to what shall appear to the court to be the merit of the invention.

The great difficulty as it appears to me in the exercise of such a function by a court, is the embryo state of the invention at the time of the original application for provisional protection. Mr. Grove appears to have some sense of this difficulty by his inserting the qualification expressed in the words "as far as they could be at such a stage" with reference to the preliminary discussion of the merits of the invention. But the difficulty is more likely to be brought home to the mind of a patent agent than of a barrister, because a patent agent is ordinarily consulted on inventions prior to a patent being taken out, and he suggests the form of provisional specification adapted to secure the essential parts of the invention, reserving the subsidiary parts to be determined by experiment in time to be inserted in the final specification; whereas the barrister is seldom consulted except upon the final specification or after this has been filed. The patent agent is necessarily more familiar with inventions in what I have called their embryo state than the barrister, and this is probably the reason why patent agents oppose the opening of provisional specifications to the public before the final document has been filed, while barristers are found to advocate it. From my own experience of patents, I am convinced that many inventions of merit cannot be duly appreciated before experiment, and that their merits could not be discussed at all at the stage proposed, with a view to determining whether they were worthy in the eyes of a court of being protected by patents.

I altogether doubt the practicability of the following suggestions of Mr. Grove:—

> "In considering the question of what was the subject of a patent, the court would not, if it did its duty, take the narrow ground hitherto adopted, and say that everything was a proper subject for a patent which was new, in the sense of no one having practised it before, and of its having some, though ever so little, utility: it would look to substantial merit, to inventions which promised efficient service to the community, and adjudge accordingly. It might possibly, in rare cases, reject a meritorious invention, but this would be less injurious than the present state of doubt and confusion. By having the power of naming the time for which letters-patent should be granted, the monopoly would bear a proper relation to the merit of the invention."

I doubt the practicability of the court choosing out of the mass of inventions with anything like accuracy those "which promised efficient service to the community," and assigning to them their respective values so as to give to each a term of patent right which would bear a proper relation to the merit of the invention. Mr. Grove meets the supposed objection that "the court would, as the attorney or solicitor general do, grant all demands, or so large a number of them as to make it hardly worth while to have the discretion vested in it," by referring to the mode in which the Judicial Committee of the Privy Council have been in the habit of exercising their discretion with respect to prolongations of patents. But this I submit is quite a different case. Patents are fourteen years old when presented to the committee, evidence of their practical utility and inadequate remuneration is produced; and the practice has been simply to ascertain whether any case of hardship on the patentee exists, and if so, to grant a prolongation of the term, but if otherwise, to refuse it.

The exercise of a discretion of this kind is as different from that proposed as a retrospective decision is from a prospective. In the one case there exist data on which to found a judgment, while in the other many points require to be settled by experiment before any accurate judgment can be formed. Then there is a very serious objection to the plan in the time the investigations would occupy. At present there are three thousand applications for patents in a year. How long would it take to dispose of these so as to give to each the attention which is implied in hearing a discussion of their respective merits, with a view to the exercise of a discretion to the extent of withholding a grant or of proportioning the length of its term to the value of the invention?

On the foregoing grounds, with others, I venture to doubt the practicability of any plan of preliminary investigation of the merits of inventions before granting patents, whether in the form proposed by Mr. Grove or in any other form that I have known to be suggested. Preliminary investigation can only be d to check irregularity of practice. But I pass now to the second branch of judicial labour proposed to be assigned to the court—that of trying patent causes.

Here I am happy to find reasons for accepting the statements of Mr. Grove, and it is undoubtedly a satisfaction to my mind to feel that the cause of a special tribunal for trying patent causes has the benefit of so able an advocate. I quite agree with him that "the judges of the new court should be chosen from practising barristers of a certain standing." I also admit that "nothing qualifies a man for testing the truth in judicial investigation so well as practice at the bar." Mr. Grove's qualified acceptance of the suggestion of a scientific assessor to sit with the judge, appears to me likewise to be correct. The judge ought to be unfettered, and alone responsible for the conduct of the case; and therefore in those cases in which it was advisable to afford him scientific aid, the scientific man or men called to aid him should be subject to his control. I think with him that it would be better for the judge to "have power, as the law officers now have by section 8 of statute 15 and 16 Vict. c. 83, to call in occasional aid," than to appoint a permanent assessor. Mr. Grove makes the following valuable remarks on the probable working of the court:—

> "In trying patent cases the court, by having its entire attention directed to scientific matters, would be able to deal more satisfactorily with scientific witnesses, woulde detect their fallacies and apprciate their sound evidence, and thus be able to unveil the truth to a jury with more success, be it said with all respect, than judges who have only occasionally to devote their minds to a class of subjects requiring a peculiar apprenticeship fairly to master them. The court would analyse matters of fact, leaving them to a jury, so as to do away in some degree with the advantage gained by the more skilful advocate. The discretionary power of granting new trials in the hands of such a court would be of great advantage. All the interlocutory matters, such as the settling particulars of breaches and notices of objections, would be more fully gone into and more satisfactorily settled by such a court than they are in the present scramble before a judge at chambers."

All barristers of experience in patent trials know the trouble of settling particulars of breaches and notices of objections, and I think they would bear out Mr. Grove's remark in characterising the present proceedings before a judge at chambers as a "*scramble*." The following additional remarks of Mr. Grove on the probable working of the court are also worthy of attention:—

> "Questions of disclaimer and memoranda of alteration would be fully and openly discussed before the court, and the publicity of these matters would not only have its recognised effect of compelling the court to give the fullest and most careful attention to the questions on this head brought before it, but would enlighten those sections of the public interested in the patents discussed, as to the real merits of the patentees. These discussions would have the proper effect of giving increased stability to meritorious, and of exposing frivolous patents."

Mr. Newton has repeatedly drawn attention in his journal to the defects in the present mode of administering this part of patent law; and to me it has appeared to be the most defective part of the functions of the law officers, arising no doubt from the little time which they have at command for the purpose, compared with the great amount of attention which some points connected with disclaimers and memoranda of alteration require. It is probable that the proposed court would do much towards remedying the defects in this part of the administration of the law.

Mr. Grove also says:—

> "The court would have the powers now vested in the law officers of the Crown, in the judges trying patent causes, and hearing arguments on them in banc, and in the Judicial Committee of the Privy Council."

By this arrangement there would be a consolidation of the functions of the present separate authorities, which would in all probability have a tendency to give strength and consistency to the proceedings: besides, it would avoid the necessity of applying to different courts, with the risk of opposite decisions, thereby incurring useless expense. The argument of the Lord Chancellor with reference to the Bankruptcy Bill appears to me to be applicable also to such a court as this, wherein he speaks of

> "The benefit that would result from the establishment of an all-sufficient tribunal, that would be able to administer justice in all its branches, and would set the example of a court competent to discharge its duty without dancing the suitor to and fro, to enable him to get a fragment of justice in one place and another fragment elsewhere."

The same learned authority said—

> "We in England suffer under evils which have grown up from the fact that a great portion of justice is administered by one tribunal, and another equal or larger portion of justice is administered by another; the tribunals being frequently antagonistic and opposed to each other: so that, in point of fact, justice is constantly elaborated by a system of counter processes."

This remark might be abundantly illustrated by a reference to the history of many patent cases, and who will doubt the anomaly of such a state of things? Hence it will appear that Mr. Grove's proposed court would possess an element of strength in its concentration of jurisdiction.

Having thus shown in what respects I differ from Mr. Grove, and in what respects I agree with him, I will now proceed to offer a few suggestions of my own. On this point it is difficult to avoid repeating myself in a manner that may be considered tedious by some who may have read portions of my letters in the *Engineer*. I do not however propose going over much of the ground traversed in those letters, but will content myself with making a mere allusion to my leading purpose in writing them, and a few remarks in connection therewith.

I have all along contended that the chief requisite in a good patent tribunal is an efficient means of interpreting the specification at the outset of the proceedings, and that the present tribunal does not supply this—hence its great defect. I am ready to admit that the specification does eventually get an interpretation under the present system of trial, but that is usually not until, after several years of litigation, the case arrives at the House of Lords, the highest court of appeal. The objection to the existing mode of investigation is that it is too circuitous. There is often indeed a great show of precision in language, while there is really a wide divergence from the essential matters of the specification. The counsel and scientific witnesses have a natural tendency to twist the language of the document to suit their particular purposes. Then there is all the by-play and manœuvring to produce an effect on the jury. All this comes in the way of an interpretation of the specification. It would occupy too much time to illustrate these points by referring to cases. I will only refer to Heath's case, which has been so fully reported and commented on by Mr. Webster, who remarks thus:—"A considerable degree of uncertainty is unfortunately an incident of the legal proceedings necessary for the maintenance and protection of property in inventions; but Heath's is a most remarkable case of such uncertainty." In this case the claim in the specification was thus expressed negatively: "Not the use of any such mixture (the particular mixture described) of cast and malleable iron, or malleable iron and carbonaceous matter, but only the use of carburet of manganese in any process for the conversion of iron into cast-steel." The claim was also thus expressed positively: "The employment of carburet of manganese in preparing an improved cast-steel." Now in this case the patentee was non-suited in the Court of Exchequer, on the double ground of the elements of carburet of manganese being so much cheaper than the composite substance as to make it a new invention, distinct from that of the patent, and of the insufficiency of the evidence to prove the formation of carburet of manganese during the process of using the elements, so as to bring the alleged process within the terms of the claim.

The specification in this case seemed to be used as a subject for the trial of logical exercises. Looked at from one point of view it was shown to mean one thing, and from another point of view another thing. But what was held to be its real meaning is not stated: we are left to gather this from the terms of the non-suit, which are unfortunately ambiguous. The assertion that the use ot the elements was a new invention, on the ground of its comparative cheapness, seems to imply that the specification was held to include only the more expensive mode of using the composite substance previously prepared. There seems to be no clear distinction drawn between a difference in degree and a difference in kind. The one passes into the other (it seems to be said) at a *certain* point, but *where* we are left to guess. Then the other ground of the non-suit seems to imply that the specification was held to cover the formation of carburet of manganese *per se*—otherwise what could it matter whether it was formed or not, as it was confessedly not formed in the manner directed in the specification. Hence it appears that no clear opinion as to the specification was pronounced by the non-suit. On the first ground the document seems to be declared to be confined to the use of carburet of manganese in the expensive mode—that is as a composite substance previously prepared; on the second ground it seems to be declared to cover the use of carburet of manganese in any manner, that is as extending to the elements. And then, if this point of the two conflicting constructions of the document be followed throughout the whole of the decisions (ten in number) it will be found that such ten decisions were respectively governed by the particular side of the alternative that happened to be adopted. One class of opinions (adopted by seven judges) construed the specification as covering the use of carburet of manganese without limitation, and affirmed the infringement of the patent by the use of the elements; the other class, adopted by four judges and two law lords, construed the specification as limited to the use of the composite substance previously prepared, and declared that the use of the elements was no infringement.

Now the important question of principle in the trial of patent causes—illustrated by this slight reference to Heath's case—is, *that the conclusion of the case is governed by the opinion formed of the specification*, and this principle is universally applicable in patent cases. Hence the proper test of sufficiency to be applied to a patent tribunal is this,—What means of interpreting the specification does it possess? The precise form of constitution for the court is comparatively unimportant provided it possess the means of interpreting specifications readily and accurately. I think that, whatever form were adopted in the first instance, it would have to be modified as the work on the hands of the court increased; therefore it is advisable as a preliminary measure, to adopt as simple a form of tribunal as is compatible with the end in view. The machinery can always be increased.

I would thus suggest as an experiment the mode of trial adopted in the case of Wheeler *v.* Turner. In this case the parties agreed to refer the matter to a patent agent chosen by each party, who before sitting as arbitrators were to choose an umpire. The arbitrators and umpire had the case laid before them at two sittings of about four to five hours each, at which they took notes of the evidence separately. They then adjourned over a day in order to look over their notes, and afterwards met and disposed of the case. The form of proceeding was, to take a deed of agreement, previously arranged by the solicitors of the parties, simply stating the issue to be tried, as the basis of the investigation, and then to examine the case submitted by each party with reference to its bearing on the questions required to be answered by the arbitrators. The case for each party was stated by counsel, who abstained from introducing irrelevant matter, and avoided "topics of prejudice" and mere speech-making. No professed scientific witness was examined, the arbitrators not standing in need of any such help; so that the usual consumption of time in bringing out and answering hypercritical statements on the specification was avoided. The evidence was exclusively of a practical nature, the witnesses were all men practically acquainted with the manufacture in question, either as workmen or as directors of work; not accustomed to the practice of giving evidence, and therefore amenable to the control of counsel. And it did not appear all through the investigation that any point of importance bearing on the science of the case failed to be elicited from want of power in the examiners to reach the full meaning of the witnesses: so that the arbitrators had full confidence in the evidence as it appeared on their notes. It will be easily understood by anyone who has had any experience of the labour and expense in time and money to the parties in ordinary trials how much was saved by adopting so comparatively simple a mode of settling a patent case.

The only question is as to the quality of the decision in such a case as this. It may be asked, what security is there that good arbitrators can be found? Probably Mr. Grove would have some doubts on this point, for he says:—

> "The large majority of those who have had opportunities of seeing or trying the difference between what is termed a lay arbitration and a legal one, will need no argument to convince them of the superiority of the latter, 'cuique in suâ arte credendum'; and few, if any, professions require such training, moral as well as intellectual, as does that of an advocate or a judge."

Now, I have endeavoured, in letters published in the *Engineer*, to answer various objections to arbitration in patent cases, I will, therefore, at present only refer to Mr. Grove's objection in particular, which it appears to me may be answered by claiming for the arbitration in the case of Wheeler *v.* Turner just described the quality which he contends for as essential. The arbitrators were professionally trained in the law and practice relating to patents. They were adjudicating in their own art, and were therefore to be believed.

The only valid objection that I am aware of to such arbitrations, is the difficulty of getting the parties to consent to a proper reference. The case of Wheeler *v.* Turner was the unusual one of both parties requiring merely a settlement of their just claims. If, however, a few reasonable parties would set the example, and the cases so tried were fully reported, patentees would probably be led to realise the advantages of such a mode of trial, not only in point of economy, but also in point of clearness and intelligibility in the settlement of rights. Then the courts of law might in time be brought to see the advantage of referring questions on specifications to arbitrators properly chosen, whose interpretation of the document they might accept as the basis of their own determination of legal rights between parties. In this way it might be possible to arrive at the best form for a permanent special court. It is time, however, that my remarks should be brought to a close, although many points have been necessarily omitted, and others treated too briefly to convey an adequate idea of my meaning to persons who have not given much time to the consideration of the subject. Still, I trust enough has been said to form a basis for useful discussion; I will, therefore, in conclusion, shortly recapitulate the several points submitted.

The amount of property invested in patents, of which there are at this time about twelve thousand in force, surely entitles it to be rescued from its present state of insecurity, arising from the defects in patent tribunals, not only confessed but frequently dwelt upon by the judges, who, evidently feel that patents have outgrown the capabilities of the present system of trying them. They are, confessedly, too special to be properly dealt with by the ordinary legal machinery. Mr. Grove, as a lawyer, eminent in science, and in the knowledge of patents, sees so many defects in the present system, that he strongly recommends the establishment of a special court for trying patent causes, the judges of which by confining their attention to patent cases would acquire power to deal with them effectually. But then, his suggestion is clogged with what appears to me an impracticability in one of its branches, that which refers to the preliminary investigation of inventions, for the purpose of determining whether or not they are worthy of patents, and if so in what proportions their merits are to be acknowledged in the length of the term of patent right allowed. In all but this feature I think Mr. Grove's suggestion valuable, especially in his consolidation of legal authority. Still, I think, the precise form of the court may be varied, so long as it possesses the means of readily and accurately interpreting specifications. Hence it seems advisable to try a simple form of arbitration like that described, as an experiment, with a view of determining what would be the best mode of securing a ready interpretation of specifications and settlement of rights, in order that eventually powers might be given to enforce acquiesence in a reference to arbitrators or to a special court from the courts of law. I will only add that, as a patent agent, I have naturally felt a desire to do all in my power towards finding a remedy for the acknowledged defects in the administration of patents, which desire is equally felt by other members of my profession, who with myself hold it to be a duty incumbent upon us to seek to place patent law on as efficient and permanent a footing as possible.

On the Application of Workshop Tools to the Construction of Steam Engines and other Machinery.

By J. Robinson.

In treating the subject of workshop tools, or, as they have been less technically described, "machines for making machines," it had been first intended to trace in a brief manner the history and progress of these machines from an early date to the present time; but it was subsequently decided to limit the scope of this paper to a recent period, during which, the rapid progress made in the adaptation of steam-engines and machinery to the purposes of locomotion and almost every branch of manufacture and agriculture has stimulated the energies of mechanical minds to discover and apply the means, not only of keeping pace with the constantly increasing demands made upon them, but also of treating in a commercially remunerative manner the ponderous masses of metal required for our steam marine, and other cognate branches; while they have at the same time been obliged carefully to keep in view the best mode of obtaining the accuracy needed in the application of constructive machinery to those minute details which have been until lately attempted only by manual labour.

LATHES.

The best known and most commonly received constructive machine, is the "lathe" or "turning bench," embracing as well the tiny foot-lathe as the massive machine required for turning our large marine cranks, and the centres of our paddle-wheels, and railway turntables. Since the invention of the slide motion, these machines have gone on rapidly increasing in accuracy of construction, as well as in general dimensions; and the time is easily recalled when, in our machine factories, the beds or benches employed for hand turning-lathes (*i.e.* where the steam-engine turned the machine, but the hand of the workman fashioned the object revolving in it) were simple beams of timber faced with sheet-iron, and supported on cast-iron feet or wooden packing blocks. These are almost universally superseded by cast-iron beds planed by machine, and adjusted by the file; and in all well-furnished workshops compound slide rests are now employed, at least, wherever the lathe is geared with sufficient power to permit their use, and the self-acting principle is advantageously and simply applied to them by means of an eccentric fixed upon the revolving lathe spindle, which actuates a plain lever, and draws down a chain passing over pulleys attached to any convenient place overhead, descending to a ratchet wheel upon the slide rest screw, which receives an impulse at each revolution of the lathe, and the tool is thus made to pass over the surface of the work. A modification of the ordinary compound slide rest is frequently employed for turning spherical work, whether externally or internally; the rest for this purpose being formed by the addition to the top slide of a circular worm table actuated by a corresponding worm worked by the hand of the operator. Besides this simple application of the slide rest principle, the number of self-acting slide lathes is rapidly increasing; in these the tool travels unaided by the workman, not only along the cylindrical surfaces of objects, but also transversely to the axis of the work, thus frequently permitting one workman to employ two or more lathes at the same time. Another means of increasing the production of work from these machines is that of using several cutting tools in one lathe at the same moment. This is done in the "duplex" arrangement, by which one tool is made to cut upwards in the ordinary way at one side of the object, while a second tool placed opposite to it is taking another cut downwards, the cutting edge of the tool being reversed accordingly. This operation, whether effected in a slide lathe or in a compound rest lathe, will be readily understood to be a means of saving time, and thereby of decreasing the cost of the several parts of machines capable of being so operated upon. It may be interesting to state that this multiplication of the number of cutting tools in one lathe has been carried to the extent of *seven*, all of which are controlled by one workman; three of them being placed on the side of the bed next to him, and four on the opposite side, all worked by self-acting motions, and thus giving the operator time to watch the action of each. This lathe has been constructed chiefly for the purpose of turning cranked axles for locomotive and other engines, and when so employed, the three tools on the side next the workman are brought to bear longitudinally upon the cylindrical parts of the axle, while the four opposite tools, their cutting edges downwards, are made to act transversely upon each of the sides of the two crank sweeps,—the time for effecting the whole operation of turning the axle being thus reduced to a minimum. A very frequent application of the self-acting compound slide rest is to double face-plate lathes employed for turning the rims and tires of locomotive wheels; many of these "wheel lathes" are constructed with four such slide rests (*i. e.* two to each face plate), one of them holding the downward, and the other the upward cutting tool, and placed of course at opposite sides of the objects being turned, the two faces of the rims or tires of the wheels, and two of their sides, being thus operated upon at the same time. Another form of lathe now in frequent use is the gap or break bed-lathe, which permits of an object being turned in it larger in diameter than that which the actual height of the centres above the ordinary surface of the bed would take in. These gap lathes are of two kinds, one being made with a fixed gap always existing, and without the means of closing by pushing up the bed to the headstock, and the other has the fixed headstock placed on the bolster, bolted to a long planed base plate, on which the bed carrying the movable headstock and slide rest can be shifted at pleasure, so as either to be in contact with the fixed headstock, or at such a distance from it as the object of large diameter may require. The last class of lathe to which it is intended to refer is the screw cutting-lathe, which is a modification of the sliding lathe, and has the sliding tool carriage put in motion by means of an accurately cut guide-screw and nut, the number of revolutions of which, in proportion to the speed of the headstock required to give the various pitches of screws, is regulated by the application of change and intermediate toothed-wheels, placed at the end of the lathe, and capable of giving to the sliding carriage any required range of motion suited to the pitch of screw desired. Other lathes for special purposes—such as gun boring, propeller turning, and lathes with reciprocating motion to face plate—would require a larger space for their description than the limits of this paper would allow. Before leaving the subject of lathes, it may not be considered out of place to call to mind that the use of these now accurately constructed machines will fail of producing correspondingly accurate results, unless the workman be provided with the means of testing the exactness of his diameters (whether external or internal), the taper of his cones, the correctness of his curves, and the parallelism of his cylindrical objects, which cannot be done without the use of carefully-constructed standard gauges and templates; and these are now preserved from a too-rapid deterioration by the hardening process which their surfaces, whether of iron or steel, undergo.

PLANING MACHINES.

The form of our earlier planing machines, like that of the older lathes, was very simple, although the invention took place at a much later period; but no long time elapsed before self-acting movements were applied to every required change of direction of the cutting tool over the surfaces to be planed, whether these were horizontal, vertical, or at any angle whatever to the plane of the table. The use of the rack and pinion, and also of the screw and nut for moving the table, soon succeeded the original chain motion, the latter especially being employed in those machines where the cutting edge of the tool is reversed at each change of direction of the table, so as to cut in either the backward or forward movements, the speed of the table in both being the same wherever this system of revolving tool is made use of; whilst, in the case of most machines with tool-boxes arranged for cutting in one direction only, the table is made to return at a speed considerably greater than during the operation of cutting. As in the case of lathes, so with these machines—the pressure of work to be produced in a given time led to the adoption of several tools cutting at the same moment, and this has now been carried to the extent of employing eight cutting tools at work simultaneously upon one machine, the power of moving the table being of course increased in proportion; and, in most well-fitted workshops, planing machines may be found having two, four, and even six tools, at work upon them. Many years ago large planing machines were constructed with the view of operating upon fixed objects of great weight by means of travelling tools, since in this case the weight of the tool-slide and its fittings was in most instances considerably less than that of the object to be planed: but this arrangement of machines seems not to have obtained to any extent, most of the large masses involved in the ponderous machinery of the present day being planed on ordinary machines of large size—either by traversing them on the table in the usual way, or by placing them near the side of the machine, and planing them by means of a cutting tool fixed on a standard and slide travelling with the table, and having a self-acting feed motion imparted to it at each return of the table. This mode of dealing with them is rendered almost imperative by the unwieldy size and form of the larger castings now employed for constructive purposes. An interesting adaptation to the ordinary planing machine has been made, by the addition to it of a radial arm working upon a pivot fixed vertically on a bracket extending some distance from the side of the machine, and made to reciprocate by a pin inserted in the ordinary table, on which is fixed a block capable of adjusting itself in a groove of the arm prepared to receive it; by this arrangement objects fixed upon the extended surface of the radial arm or quadrant receive a curvilinear motion when the table of the machine travels backward and forward; and when the fixed tool of the cross slide is brought to bear upon the work, the cutting lines form arcs of circles corresponding with the length of their radii, measured from the projected centre, which latter being adjustable as to its distance from the centre of the table gives great facility for producing a considerable range of curves. This apparatus has been used chiefly for the expansion links or quadrants working the slide valves of locomotive engines and for objects of analogous form. It will be well perhaps here to refer to an arrangement of machine invented a considerable time ago in this country, and recently reproduced in the United States. This machine may be called a circular planing machine, and consists of a circular table resting upon circular grooves, and made to revolve horizontally by bevil gearing underneath a cross slide carried by two vertical brackets, the slide carrying the tool-box being moved along this cross slide by a self-acting screw motion, as in the ordinary rectilineal planing machine. It will be obvious that a piece of metal bolted upon the table and thus made to revolve with it, could have a true surface produced upon it, by the tool applied to it from the cross slide above, just as would be the case if it were fixed to the face plate of a lathe, with a tool traversing in front of it. Such machines seem to be almost obsolete in this country; the lathe and common planing-machine being found to answer all necessary ends. In consequence of the extensive introduction of hardened surfaces into our higher class of engine work, it has been found necessary to employ grinding-tables to restore these surfaces to accuracy when irregularities have been created, either by the process of dipping in the case of wrought-iron, or chilling in producing cast surfaces. Such tables are of two forms—one, like that of an ordinary planing machine, the steel cutting-tools being replaced by revolving stones or emery rollers, made to act upon the surfaces of the hardened objects by lowering the tool-slide to them; and the other composed of a circular disk of copper or lead, in which grooves are cut for the reception of emery powder and oil, and on which, while revolving, the various objects are laid by skilful workmen, and the faces brought up to mathematical accuracy. In both cases facilities have been obtained for the production in our engines of that hardness of rubbing surfaces which our high pressures, and the increasing weight of the moving parts, are rendering every day more imperative.

DRILLING MACHINES.

In the process of putting together the objects which have undergone the operations of the lathe and planing machines, the drilling machine is brought into requisition to produce the holes necessary for the passage of the bolts, screws, and other means of fastening together the various parts. Since the invention of the primitive machines this class of tool has undergone considerable change and has experienced much improvement. For large holes back-geared motions are applied, resembling in principle those of a lathe headstock; and in these larger classes of drill the tool is usually moved down to the work by means of a worm or other such-like gearing, whether worked by the hand of the operator or kept in motion by the machine itself. A now increasingly-frequent form of machine is the radial drill, which usually consists of a drilling spindle mounted upon an arm, radiating like the jib of a crane from a central pivot, the length of the arc described by the drill being variable by a screw, or rack and pinion movement, attached to the arm, and the elevation of the machine from the floor being effected by similar apparatus. Some of these machines are attached to independent cast-iron columns or frames to which the pivoting brackets are fixed, while in others these brackets are simply bolted against the walls of the workshop, and thus a much cheaper and lighter machine is obtained. These radial machines are found particularly applicable where a great number of holes have to be drilled in large objects, since the drill can be brought to bear on any point, embraced in one direction by a considerable portion of the radius of the arm of the machine, and by the arc described by the radiating motion in the other—and thus, not only does it become unnecessary to move the object every time an additional hole is drilled, but the successive holes are produced exactly true with each other, and vertical to the face of the object operated upon. For special uses drilling machines have been constructed on the planing-machine type, having several drilling spindles revolving upon a cross slide in an analogous position to that of the cutting tool of a many-tooled planing machine. The objects to be drilled are fixed upon the table in the usual way; and where a number of holes are required to be drilled at regular intervals, as in the case of the roller beams of spinning machines, this is readily accomplished by a self-acting movement to the table coming into operation immediately the drills return from the holes, and bringing under them successively the points of the beams or other similar objects where the next row of holes is required. Two others forms of drilling machine are those called the slot drill and the traversing drilling machines—the intention of these machines being the production of slots or grooves in objects of almost any form by a drilling, instead of a planing or slotting process. In the slot drill the article to be operated upon receives a self-acting reciprocation by means of a revolving disk or other similar movement variable in its extent according to the length of the groove or slot required to be cut, the drill at the same time is brought down to the surface of the work in the usual way, and the feed given to it at each reciprocation: by this means a groove of any ordinary depth is produced in pins or shafts of moderate dimensions. Following upon this, came the traversing drill, having a similar end in view, but adapted for larger objects, and suited for more accurate work. In this machine the drilling headstock itself is made to travel by means of a disk movement along an accurately planed bed, the object to be grooved or slotted being fixed upon a table firmly bolted to the bed. The traverse is given by a connecting rod, worked by a stud in an indexed groove of the revolving disk, and can be varied by the workman, who is guided to the length required by the indexed groove already mentioned. This revolving disk is set in motion by an elliptical spur-wheel cast upon it, and worked by a pinion keyed eccentrically upon its shaft, so as to accomodate itself to the varying diameters of the pitch line of the elliptical wheel. The object of this arrangement is to obtain a more regular speed in the lateral motion of the tool than would result from an ordinary circular wheel and pinion, which would obviously give a very rapid movement in the middle of the length of the slot, and a very slow one at the two ends. The vertical feed motion is also self-acting, and takes place during the slowest portion of the traverse of the headstock, *i. e.*, when the pin attaching the connecting rod to the disk is turning each centre; and by this means great regularity and accuracy of effect are obtained, since the drill is not required to cut vertically and laterally at the same time. In many cases two headstocks and two tables are fitted upon one bed, so that two ends of a connecting rod or other similar work can be operated upon simultaneously; and as these drilling headstocks have also self-acting vertical feed movements, which can be used independently of the traverse motion, they can be conveniently used for ordinary round holes; and where the two heads are fixed at any required distance apart upon the bed, it is evident that any number of holes can be drilled consecutively by them, precisely at the same distance from each other. This machine has also been constructed on the cross slide or planing machine type. In this arrangement the objects pass between the vertical standards or uprights, and the slot holes, or grooves, can be produced either in a line parallel with or transversely to the axis of the object in hand, such as an engine beam, a cross-head, piston rod, or pump ram of a stationary or marine engine. The use of this class of drilling machine obviates the difficult and expensive process of making cottar and slot holes by first drilling through the object a row of cylindrical holes, and afterwards chipping and filing them by hand labour; besides which, more accurate and highly finished work is obtained from it, without any hand adjustment whatever, than is ordinarily practicable when manual labor is employed.

SLOTTING OR KEY-GROOVING MACHINES.

Next in order to the drilling machine follows the slotting or key-grooving machine. This machine was brought into use many years age, and has gradually been enlarged in size and capability, so as to keep pace with increased dimensions and weight of the masses, as well of wrought as of cast iron, now desired to be operated upon. Its first form was one which the name of key-grooving engine describes—viz. a machine for cutting the grooves in wheel bosses or naves, to receive the keys by which they are fixed upon their shafts or axles; subsequently other uses were discovered for this machine, the main feature of which is a virtually reciprocating tool, and convenient motions were added to the tables fixed upon the underpart of the framework—the result being an admirable machine, having self-acting circular, longitudinal, and transverse motions applied to the tables, by which means the scope of the machine is extended to the production of all forms of outline to which a tool working vertically can be applied, the paring or chiselling operation being now perhaps more frequently employed in this machine than in the first one of "key-grooving." A very useful modification of this machine has been constructed, in general arrangement like the bed and table of a planing machine, having two pair of uprights or standards with cross-beams attached to them; on these are worked slotting tools having a moderate length of stroke, and capable of receiving a transverse as well as a longitudinal motion, so that the two tools can be brought to bear upon the vertical surfaces of any large object fixed upon the table; and thus, at the same time, can be pared and slotted two surfaces, whether of curved or rectilinear outline. The primary object of this arrangement seems to have been the shaping of the edges of locomotive frames, several of which may be placed one above another on the table, and their edges brought simultaneously to the required form. The two tools of the machine working at the same time expedite the completion of the work in hand, and thus an economy of time and labour results.

Following upon the slotting machine, with its vertically working tool, comes the more recently invented shaping machine, called by our French neighbours the "limeuse" or "filing machine." The tool of this machine reciprocates horizontally, and in its simplest form is often called the "steam arm;" in this the stroke is usually short, say six inches, and no quick return-motion is given to it; the surfaces cut by it are flat only, and they are traversed along under the tool by a ratchet movement working a screw, having its nut fixed in the table on which the work is placed. The more advanced form of this machine is that in which the work is stationary, bolted on tables fixed to the bed or frame of the machine, and the tool moved along in a travelling head actuated by a ratchet motion and screw, in a somewhat similar way to that of the table of the steam arm. This mode of operation gives facilities for cutting larger objects with more extended surfaces, and at the same time permits of curvilinear and cylindrical surfaces being produced—the former by a sector and worm motion on the tool box itself, giving the tool a radial action; and the latter by fixing the cylindrically shaped object on a revolving mandrill made to rotate by a self-acting worm and worm-wheel motion attached to the bed of the machine, the tool in this case merely reciprocating in the same line without having traverse motion imparted to it, the rotation of the work itself bringing the successive parts of its surface under the cutting edge. Various arrangements have been applied to this machine to render the speed of the tool greater on returning from than when making the cut—one by means of a crank arm fixed upon a spur wheel, the point of connection with the reciprocating arm being variable within the limits of the eccentricity of the crank arm, which produces a corresponding increase of speed in the return motion. Another and very simple method is the application of a slotted link radiating from a fixed point and giving motion to the cutting arm at the other extremity. A block is made to slide in this arm worked by a pin projected from a disk to which motion is given by ordinary spur gearing; the greater the amount of the eccentricity of this pin the longer is the stroke of the arm and cutting tool, and the greater the difference between the cutting and returning speed imparted to it. The length of stroke applied to these machines is ever increasing, and many are now fitted up with two or more cutting heads upon one bed, so as to give greater facilities to the workman, and to enable him to attend to more than one cutting tool at the same time. The last form of shaping machine to which it is intended to direct attention is that used for the purpose of shaping the sides of nuts, and the heads of screws. These machines have been usually made with revolving cutters: two of them are fixed upon one revolving spindle, both toothed on the disk faces and placed at that distance as under which allows the exact finished dimension of the nut or screw head to pass between them. A series of nuts, varying in number according to their size, is then placed upon a long mandrill, fixed by jaws and a centre point to the dividing plate of the travelling slide, and so adjusted as to be embraced between the revolving cutters, which as they progress finish at once to the required dimensions two opposite sides of the range of nuts; all the spring and jar incidental to a one-sided cut being removed by the resistance afforded by the operation of the second cutting face. Such machines are readily applied to a variety of other purposes, such as grooving screwing taps, cutting out forked joints, getting up the narrow edges of such joints, and a large class of work of a similar character; the form, diameter, and speed of the circular revolving cutters being varied to produce the results desired. A machine of a somewhat analogous character is the wheel cutting machine, constructed for the purpose of cutting the teeth of wooden or iron wheel patterns or models—whether these are of the ordinary spur form, or for bevil, mitre, or worm wheels. In the earlier machines, the wooden or iron pattern required to be cut is placed upon a horizontal spindle, under or at one side of which the headstock and its revolving tool is fixed upon a slide of sufficient length to travel across the toothed face of the pattern. Some of the more recent machines have been made to cut the pattern and other wheels while fixed in a vertical position; and as in much of the spinning machinery now in use, wrought-iron toothed wheels are employed, it was needful to produce more simple apparatus for cutting them—amount of production in this case being a greater desideratum than great exactness of form and finish. The production of the revolving cutters employed in these machines at a cheaper rate than was possible by hand turning and shaping, has been accomplished by the invention of the *pentagraph* cutting machine, in which, after the turning process, the serration or toothing of the cutter disk is effected by small revolving cutters actuated on the pentagraph principle of adjustable proportionate arms, setting out the proper curves, and keeping the cutter to its work with the most minute accuracy: without this, it is obvious that these cutters would be most costly—and even now, with all modern appliances for their production, the value of each in proportion to its size is still considerable.

BOLT AND NUT SCREWING MACHINE.

A machine which has made rapid progress of late years is that used for cutting the threads of bolts, screws, and nuts. Originally of simple form and rude construction, the results obtained from its use were of a similar character—indeed, in most cases, stocks and dies with their corresponding taps, all worked by hand, were the sole means within reach of the mechanic for the production of the bolts and nuts he required. Many forms and arrangements of machine are now used for bolt and nut cutting, most of them consisting of a revolving head, somewhat like a lathe headstock fitted with cone speed-pulleys to vary the number of revolutions according to the diameter of bolt or nut to be cut. The cutting dies are fixed in a box attached to this head, and the bolt is inserted into a sliding standard travelling upon the bed in front of the head containing the dies. In most cases the process of passing through the dies is repeated twice, and even three times for larger bolts, until the requisite size and quality of thread are obtained. When nuts are required to be cut, they are usually fixed in the sliding standard, the tap being inserted in the revolving head; the standard containing the nuts is then forced up to the tap which enters the hole of the nut-formed taper for the purpose, and by the process of passing through it a proper thread is produced. Recently a very ingenious bolt and nut cutting machine has been introduced from the United States, in which the cutting dies consist of three separate tools, arranged concentrically in the die box, and kept up to their work by curved inclines fixed upon the die-holding box; the plate forming the front cover of this box has fixed upon it three curved inclines corresponding with those of the die box, the die pieces are notched so as to fit upon these inclines, and by these notches the dies are drawn back when the bolt is screwed, so as to permit it to be withdrawn from the dies. This internal portion of the box holding the dies is capable of being worked backward and forward by the gearing of the machine itself; this backward and forward movement is produced by employing spur wheels of different diameters keyed upon hollow shafts, one driving the die box when cutting, and the other thrown into gear by a lever and friction clutch-box; the speed being such as to over-run the die box, and thus cause the curved wedges to withdraw the die pieces to their widest extent by means of the notches before mentioned; when the lever is released the smaller wheel is thrown out of gear, and the dies resume their cutting position. This machine works thus: The bolt is fixed into the sliding carriage concentrically and accurately by means of holding dies simultaneously brought together by right and left handed screws; it is then pressed into the dies by means of a ratchet lever motion, and the dies being formed like chasing tools, but with some taper on their cutting faces, completely turn out the thread from the surface, and producing at one passage of the bolt a perfectly finished thread; when by means of the lever and inclined wedges, the die pieces are at once opened, and the bolt can be withdrawn instantaneously without stopping the machine or reversing its motion, and thus a great economy of time is gained, and the work done is of superior quality to that where the thread is compressed and drawn out by ordinary dies. Nuts are cut in this machine in the method above described, for the ordinary construction of machines.

STEAM HAMMER AND RIVETING MACHINES.

It will be sufficient for the object of this paper to mention very briefly the facilities which now exist for the economical production of work in the forging and boiler-making processes, as compared with the state of things some twenty or thirty years ago. The great agent in economising labour in the forge and smithy is the steam-hammer, in its various applications. Originally adopted by engineers, more perhaps for the purpose of working up economically the scrap wrought-iron produced in their own establishments, it has now become the necessary adjunct of every well-mounted smith's shop, and numbers will be found in most of our engineering establishments—not only working up the scrap iron there to be obtained, but producing forgings of large size, and stamping under well-arranged dies all possible shapes of smiths' work, the "fins" or overplus left on which are rapidly sheared away by powerful shearing machines, and thus the productions of the steam-hammer are in many instances passed forward into the turning and planing shops, without the intervention of a smith and his assistant hammermen. Steam-power has been likewise usefully employed in smaller classes of machines for forging bolts, rivets, and other articles of that nature, where a large number of objects of similar form are required. Punching and shearing machines of enormous power are now in constant use for punching plates 1¼ inch in thickness, and shearing bars, plates, &c., up to 3 and even 6 inches; so that all the cutting processes are accomplished either by their means or the employment of circular saws running at high velocities, and brought to bear upon the iron hot from the hammer, from the rolls, or from the smith's fire. The operations of the boiler-maker are now much facilitated by the employment of steam for the riveting process; several adaptations of the steam riveting machine have been invented, all of them having some peculiar excellence. The work produced is of first-rate quality, tighter in most instances than where hand-labour is employed, though more careful putting together of the plates is rendered necessary; and of course the operations are much more rapid where suitable lifting cranes and gearing are brought into play for the easy manipulation of the large objects to be operated upon. A riveting machine originally constructed to work by steam has recently been modified to suit the application of hydraulic power, and with results in every respect satisfactory.

From this rapid survey of the chief classes of tools applied to the construction of steam-engines and other machinery, it will be seen that the means now placed at the disposal of the mechanical engineer are vastly superior, both as to variety and excellence to those which were within his reach thirty years ago, when steam-locomotion, whether on land or in the water, made serious demands upon him, and its rapid advance stimulated the application of machinery to all those branches of manufacturing industry which were ready to spring into new and vigorous life immediately the steam-horse rendered possible the transport on a large scale of the raw produce in one direction, and the distribution of the manufactured article in the other. A measure of the increase of the production of machinery in this country since the year 1830, will be supplied by the consideration of one or two salient facts:—

1. That of the *exportation* of steam-engines and other machinery, which has progressed at the following rate:—

	£.
From 1831 to 1835 inclusive—total exports ...	845,203
1836 ,, 1840 ,, ,, ...	2,699,339
1841 ,, 1845 ,, ,, ...	3,500,565
1846 ,, 1850 ,, ,, ...	4,940,939
1851 ,, 1856 ,, ,, ...	8,579,533
1856 ,, 1860 ,, ,, ...	17,756,136

2. That during these thirty years the whole of our railway system, with its thousands of locomotives and concurrent machines, has been built up.

3. That during the same period nearly all our existing steam-vessels, as well for commercial as for governmental purposes, have been constructed; and,

4. That our exportation of manufactured cotton, woollen, linen, and silk goods, has jumped from the sum of £38,000,000 in 1831, to the enormous sum of £132,000,000 in 1860.

Without the aid, then, of *labour-saving* tools, no one can suppose that the immense increase in the production of machinery, indicated by the foregoing facts, could have taken place—we must, on the contrary, without them have proceeded at a very much slower speed in every department. And when we consider that the workshop tools themselves, as well as the machinery produced by their aid, have been the handiwork of one of the best remunerated classes of our population, it may well be admitted that not only do these tools deserve the appellation of *labour-saving* machines, but also the apparently anomalous one of *labour-making* machines; since, as in the cotton manufacture, so in the engineering trade, the increase in the number of workmen employed has been very nearly proportionate to that of the tools invented for facilitating the various stages of mechanical construction: showing thus that the application of machines to any manufacture whatever tends not to diminish, but rapidly to increase the number of workpeople employed in connection with it.

Freight as affected by Differences in the Dynamic Properties of Steam Ships. By CHARLES ATHERTON, Chief Engineer, H.M. Dockyard, Woolwich.

The national importance of steam shipping is a theme which demands no demonstration, and any attempt to originate, promulgate, and popularise inquiry into the comparatively economic capabilities of the steam ship, as devoted to the international conveyance and interchange of the products of nature and of manufacturing art, is a task which requires no laboured introduction in support of its being favourably received for consideration by an association devoted to the advancement of science.

The former papers on "Tonnage," "Steam Ship Capability," and "Mercantile Steam Transport Economy," which the author of this further communication has been permitted to present to the British Association, and which appear in the volumes of its Transactions for the years 1856, 1857, and 1859, were devoted to an exposition of the technicalities of the subject as respect the mutual quantitative relations which displacement, speed, power, and coal hold to each other in the construction and equipment of steam ships, with a view to the realisation of definite steaming results. So far, therefore, these investigations have had reference to the constructive equipment of steam ships; but the course of inquiry now submitted for consideration is a practical exposition of the extent to which the expense per ton weight of cargo conveyed is effected by the various conditions of size of ship, dynamic quality of hull with reference to type of form, weight of hull with reference to its build, the economic properties of the engines with reference to the consumption of the fuel and the steaming speed at which the service is required to be performed; all which circumstances respectively, and in their combinations, affect the economic capabilities of steam ships for the conveyance of mercantile cargo, and consequently freights charged, to an extent not publicly known because hitherto not specially inquired into nor promulgated by the press, and which in the distinctive details above set forth do not appear to have been duly appreciated even by the parties most deeply concerned in the mercantile control and prosecution of steam shipping affairs. The aggregate expenses incidental to the prosecution of steam transport service must generally regulate the average rates of freight at which goods are conveyed; and seeing to what an extent the ultimate cost of manufactured goods is dependent on the cost of transport, often repeated as freight charges generally are in the various stages of transition of material from the raw to its manufactured condition, and its ultimate consumption as a manufactured article, it becomes evident that this investigation especially concerns the manufacturing interests of the country. Economy of price, inducing quantity of consumption, is the characteristic feature of the manufacturing enterprise of the present day; and it is the absolute cost of goods which affects consumption, irrespectively of the various causes in detail by which the costs may have been enhanced. Under these circumstances, it is remarkable to what extent the manufacturing interests, though keenly alive to legislative imposts, and sensitively jealous of legislative interference in the control of labour as affecting the cost of manufacture, pass wholly unheeded deficiencies and imperfections in the practical control of shipping with reference to freight charges, though equally affecting the ultimate price of manufactures. Such incongruity demonstrates the necessity for popular exposition and inquiry into the various circumstances and combinations of circumstances which directly affect the expenses incidental to the conveyance of merchandise by steam ships, and by which the rates of freight are in the aggregate necessarily regulated. Freight, therefore, is the text of the following discourse, to which attention is directed under the various aspects of steam ship construction and management by which freight charge is affected, and which may be classified under ten heads or sections, as follows:—

Section A.—FREIGHT, as affected by variations of the size of the ship by which the service is performed.

B.—FREIGHT, as affected by variations in the constructive type of form of the hull.

C.—FREIGHT, as affected by variations in the working economy of the engines, with reference to the consumption of coal.

D.—FREIGHT, as affected by variations in the constructive weight of the hull, with reference to its load displacement.

E.—FREIGHT, as affected by variations in the constructive type of form, combined with variations in the working economy of the engines.

F.—FREIGHT, as affected by variations in the size of ship, combined with variations in the constructive type of form, and in the working economy of the engines.

G.—FREIGHT, as affected by variations of the steaming speed at which it is required that the service shall be performed.

H.—FREIGHT, as affected by variations of the size of ship, combined with variations of speed.

I.—FREIGHT, as affected by variations of the speed, combined with variations of the working economy of the engines.

K.—FREIGHT, as affected by variations of the speed, combined with variations in the type of form, working economy of the engines, and weight of hull.

It will be observed that it is not proposed to determine the actual amount of prime cost expenses incidental to the prosecution of steam ship enterprise, by which the scale of freight charge may be chiefly regulated, but it is proposed to demonstrate, with reference to a specified unit of performance, the ratio or comparative scale of cost, in which the prime cost expenses incidental to the conveyance of cargo per ton weight of goods conveyed on a given passage is (*cæteris paribus*) affected by each of the various circumstances or conditions set forth under the ten different heads above referred to.

The fundamental consideration on which it is proposed to base this investigation is this, that within moderate limits of variation the investment incidental to the fitting out of steam ships for commercial transport service is approximately proportional to the quantity of shipping as measured by the constructors' load displacement of the ships, and the amount of working power employed as measured by the indicated horse-power; also that the interest on investment, upholding of stock, and all other annual expenses incidental to the working of steam ships, such as coals, stores, and wages, harbour dues, insurance, and pilotage, are approximately proportional to such investment; and further, as the mercantile service of steam ships employed on a given station generally requires that their passages shall be periodical, it is assumed in the following calculations that the number of passages made annually by each ship is the same in all the different vessels assumed to be employed on the same service and brought into comparison with each other.

It is particularly to be observed that these calculations and deductions of comparative freight charges are not of general application to different services, but have reference only to the special service which, as an example of the system of calculation for any service, has been adopted as the unit of performance, namely, the performance of a ship of 5000 tons displacement, employed on a passage of 3000 nautical miles, and steaming at ten knots per hour, the coefficient of performance by the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{I. H. P.}} = C$, being $C=250$, and the consumption of coal being at the rate of 2 lb. per indicated horse-power per hour, which data have been assumed as the base of the following tabular statement, the purport of which is as follows:—

Column 1.—Reference to divisions or sections of the subject under consideration.

2 and 21—Designation of the vessels referred to in the various sections.

3.—Size of the ship as determined by displacement at the draught to which it is intended by the constructor that the ship shall be loaded.

4.—Steaming speed at which the vessel is required to perform the passage.

5.—Co-efficent of dynamic performance of the vessel by the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{I.H.P.}} = C$.

6.—Consumption of coal per indicated horse-power per hour expressed in lbs.

7.—Co-efficient of dynamic duty with reference to coal consumed by formula $\frac{V^3 D^{\frac{2}{3}}}{W}$, W being the average consumption of coal expressed in cwts. per hour.

8.—Power required to propel the vessel at the required speed expressed in indicated horse-power and calculated by the formula: indicated horse-power$=\frac{V^3 D^{\frac{2}{3}}}{C}$.

9.—Length of passage to be performed by the ship without recoaling, expressed in nautical miles.

10.—Weight of hull, including all equipment complete for sea (exclusive of engines, coal, and cargo), taken at 40 per cent. of the load displacement.

11.—Weight of engines and boilers in working order, including all equipment for sea, taken at the rate of 5 cwt. per indicated horse-power.

12.—Weight of coal required for the passage, calculated on the foregoing data.

13.—Cargo, as determined by the load displacement less the weight of hull, engines, and coal.

14.—Investment in the hull of the ship, including rigging, furnishing, and all other equipment complete for sea, taken at £50 per ton weight of hull.

15.—Investment in the engines, including spare gear and all equipment for sea, taken at £15 per indicated horse-power.

16.—Total investment in hull and engines.

17.—Comparative rates of freight or ratios of cost expenses per ton of cargo, being proportional to the investment divided by the tons weight of cargo conveyed.

18.—Ratios of cost expenses per ton of cargo, with reference to that incurred by ship A, taken as the unit of performance, and which is expressed by the number 100.

19.—Ratios of cost expenses per ton of cargo with reference to the cost incurred by ship A, taken as the unit of performance, and which is expressed by £1 per ton.

20.—Comparative freight on 100,000 tons of goods, assuming the freight by ship A to be at the rate of £1 per ton of goods conveyed.

21.—Designations of vessels referred to in the sections.

The table (see page 307) may be interpreted as follows:—

SECTION A.—Freight, as affected (*cæteris paribus*) by variations of the size of ship.

By reference to the table referred to it will be observed that as the ship's size (column 3) is reduced from 5000 tons displacement to 4000 tons, the expenses per ton of cargo (column 17) become increased in the ratio of 49 to 51, that is, in the ratio of 100 to 104 (column 18), showing an increase of 4 per cent.; or, expressed in money, assuming £1 per ton to be the rate of freight by ship A, of 5000 tons displacement, the rate by ship A_1, of 4000 tons displacement, will be £1. 0*s.* 10*d.*, and by following the table it appears that the rate of freight by ship A_2, of 3000 tons, will, as compared with ship A, of 5000, be increased 8 per cent., amounting to £1. 1*s.* 8*d.* per ton.

The comparative freight charges on 100,000 tons of goods (column 20) by the vessel A, A_1, A_2, respectively, would be £100,000, £104,000, and £108,000.

Thus, in a merely mechanical point of view, and irrespectively of various mercantile and nautical considerations which may limit the size of ships, we see the benefit of performing goods transport service by large vessels in preference to small ones, provided that adequate cargo be always obtained, and that no delay be thereby incurred. But it is to be observed that if the 5000 tons ship A, instead of being loaded with its full cargo of 2395 tons, be loaded only with the quantity of cargo (1878 tons) that could be carried by the 4000 tons ship, A_1, the freight expenses per ton of cargo would in this case be enhanced in the proportion of 63 to 49, that is, in the proportion 128 to 100, or 28 per cent.; or, expressed in money, in the proportion of £1. 4*s.* 10*d.* to £1, the same being a higher rate by 24 per cent. than the freight charge at which the 4000 tons ship, A_1, would perform the service. By pursuing the calculations from the data adduced by the table, it will be found that the economic advantage of the 5000 tons ship A, as compared with the 4000 tons ship, A_1, will be entirely sacrificed if its cargo be reduced from 2395 tons to 2305 tons, or be only 90 tons or $3\frac{3}{4}$ per cent. deficient of its full load. Also, as compared with the ship A_2, of 3000 tons, the advantage of the 5000 tons ship A will be lost if its cargo be reduced from 2395 tons to 2218, or be only 117 tons deficient of its full load.

Hence it appears that the superior economic capabilities of large ships in a mechanical point of view for the conveyance of goods, may in a mercantile point of view be very soon sacrificed by mismanagement in assigning larger vessels for the discharge of mercantile service than is demanded by the trade, notwithstanding the economic superiority of large ships when promptly and fully loaded.

SECTION B.—Freight as effected (*cæteris paribus*) by variations in the constructive type of form of the hull.

The relative constructive efficiency of mercantile ships in a purely dynamic point of view, as respects type of form (irrespectively of materials and workmanship), is now generally recognised as being determined by their coefficients (C) of dynamic performance, as deduced from actual trial of the ships, and calculated by the following formula: $\frac{V^3 D^{\frac{2}{3}}}{\text{I. H. P.}} = C$, which may be expressed as follows:—Multiply the cube of the speed (V^3) by the cube root of the square of the displacement ($D^{\frac{2}{3}}$), and divide the product by the indicated horse-power; the quotient will be the coefficient (C) of dynamic performance.

To enter upon the various uses to which this formula is applied would be irrelevant to the matter now under consideration. Suffice it to say that the numeral coefficient obtained as above set forth affords practically a means by which the mutual relations of displacement, power, and speed of a steam ship of given type of form, and of which the coefficient is known, may (*cæteris paribus*) be deduced, and it affords a criterion indicating, whatever be the size of the ship, the constructive adaptation of its type of form for mechanical propulsion, as compared with other types of form tested by the same rule; the condition of the vessels as respects cleanliness of immersed surface, stability, and other essential properties, being assumed to be the same. And we now proceed to show to what extent, under given conditions, freight per ton of goods conveyed is effected by variations of type of form, as represented by variations of the coefficient of performance.

By reference to the table (section B), it will be observed that as the coefficient of dynamic performance is reduced from 250 to 150, the expenses become increased in the ratio of 100 to 132, or 32 per cent.; or assuming the freight by ship A, of which the coefficient of dynamic performance is 250, to be at the rate of £1 per ton of cargo, the charge by ship B_1, of the same size, but of which the coefficient is 200, will be £1. 2*s.*, being an increase of 10 per cent. and the charge by ship B_2, of the same size, but of which the coefficient is 150, will be £1. 6*s.* 5*d.*, being an increase of 32 per cent. as compared with the rate of freight by ship A, of which the coefficient is 250.

The comparative freight charges on 100,000 tons of goods by the vessels A, B_1, B_2, respectively, would be £100,000, £110,000, and £132,000.

Seeing, therefore, that variations of the type of form, as indicated by variations of the coefficient of dynamic performance, even within the limits of 250 and 150, which are of ordinary occurrence in steam shipping, affect the expenses incidental to the conveyance of mercantile cargo under the conditions referred to, and consequently affect the rate of freight to the extent of 32 per cent., the coefficient of dynamic performance which a ship may be capable of realising, being thus (*cæteris paribus*) a criterion of the economic working of the ship with reference to power, becomes a highly important matter for directorial consideration in the purchasing or disposal of steam ships.

SECTION C.—Freight as affected (*cæteris paribus*) by variations in the working economy of the engines with reference to coal.

The relative working economy of marine engines as respects the consumption of coal per indicated horse-power per hour is evidently an important element for consideration as affecting freight: to illustrate which it has been assumed that variations in mercantile practice extend from 2 lb. per indicated horse-power per hour to 4 lb. The consumption of so little as 2 lb. per indicated horse-power per hour is not usually attained, but being now admitted to have been achieved, and such having become a matter of contract stipulation, it may be looked forward to as the probable future consumption on board ship generally, although the ordinary consumption of existing steamers cannot at the present time be rated at less than 4 lb. per indicated horse-power per hour.

By reference to the table (section C), it appears that under the special conditions of the service under consideration (namely vessels of 5000 tons displacement employed on a passage of 3000 nautical miles, and steaming at the speed of 10 knots an hour), by increasing the consumption of coal from 2 lb. to 4 lb. per indicated horse-power per hour, the expense per ton of goods conveyed becomes increased in the proportion of 49 to 56, that is in the proportion of 100 to 114, an increase of 14 per cent.; or assuming the freight by the standard ship A, consuming 2 lb. of coal per indicated horse-power per hour, to be at the rate of £1 per ton of cargo conveyed, the rate of freight by ship C_1, consuming 3 lb. per indicated horse-power per hour, will be £1. 1*s.* 2*d.*, being an increase of 6 per cent., and the rate of freight by ship C_2, consuming 4 lb. per indicated horse-power per hour, will be £1. 2*s.* 10*d.*, being an increase of 14 per cent. per ton of goods conveyed under the conditions referred to.

The comparative freight charges on 100,000 tons of goods by the vessels A, C_1, C_2, respectively, would be £100,000, £106,000, and £114,000.

Section D. — Freight charge as affected (*cæteris paribus*) by variations in the constructive weight of hull with reference to the size of the ship as determined by the load displacement.

To illustrate this matter it has been assumed that the weight of hull, including the whole equipment complete for sea (exclusive of engines, coal, and cargo) may vary from 40 per cent. of the load displacement to 60 per cent., under which limitations, by reference to table (section D), it appears that under the special conditions of the service under consideration, by increasing the weight of hull from 40 per cent. of its displacement to 60 per cent., and assuming the cost of the hull to be in proportion to its weight of materials, the expenses or freight charge per ton of cargo conveyed become increased in the proportion of 49 to 120, that is, in the proportion of 100 to 245, being an increase of 140 per cent.; or, assuming the freight charge by the standard ship A, of which the weight of hull is 40 per cent. of the load displacement (2000 tons), to be at the rate of £1 per ton of goods conveyed, the rate of freight by ship D_1, of which the weight of hull is 50 per cent. of the load displacement (2500 tons), will be £1. 10*s.* 7*d.* per ton, being an increase of 53 per cent.; and by ship D_2, of which the weight of hull is 60 per cent. of the load displacement (3000 tons), the rate of freight becomes £2. 9*s.* per ton, being an increase of 145 per cent. per ton of goods conveyed under the conditions referred to.

The comparative freight charges on 100,000 tons of goods by the vessels A, D_1, D_2, respectively, would be £100,000, £153,000, £245,000.

Hence, in the construction of steam ships we see the importance of quality of material and excellence of fastening as a means of reducing weight, and the disadvantage that attends heavy-built ships, such as war steamers, for discharging mercantile service. Hence also we see the deficient steaming endurance of high-speed armoured ships, unless built of enormous size, as measured by their load displacement.

Section E.—Freight as affected (*cæteris paribus*) by variations in the constructive type of form combined with variations in the working economy of the engines.

By reference to the table (section E), it appears, under the special conditions of the service under consideration, that by an inferior type of form, as indicated by the coefficient of performance being reduced from 250 to 150, combined with an inferior construction of engines, as indicated by the consumption of fuel being increased from 2 lb. to 4 lb. per indicated horse-power per hour, thereby reducing the coefficient of dynamic duty (column 7) from 14,000 to 4200, the expense of freight charge per ton of goods conveyed becomes increased in the ratio of 100 to 179, being an increase of 79 per cent.; or, assuming the freight charge by the standard ship A, of which the coefficient of performance is 250, and rate of consumption 2 lb. per indicated horse-power per hour (giving a coefficient of dynamic duty 14,000), to be at the rate of £1 per ton of goods conveyed, the rate of freight by ship E_1, of which the coefficient of performance is 200, and the consumption of coals 3 lb. per indicated horse-power per hour (coefficient of dynamic duty 7467), becomes £1. 4*s.* per ton, being an increase of 20 per cent.; and by ship E_2, of which the coefficient of performance is 150, and the consumption of coal at the rate of 4 lb. per indicated horse-power per hour (coefficient of dynamic duty 4200), the rate of freight becomes £1. 15*s.* 10*d.*, being an increase of 79 per cent. per ton of goods conveyed under the conditions referred to. The comparative freight charges on 100,000 tons of goods by the vessels A, E_1, E_2, respectively, would be £100,000, £120,000, £179,000.

Hence, in control of steam shipping we see the importance of the coefficient of dynamic duty (column 7), as indicating the economic efficiency of the ship in a mercantile point of view, with reference to the merits of her hull and engine construction, being made a subject of contract stipulation.

Section F.—Freight as affected (*cæteris paribus*) by variations in the size of the ship, combined with variations in the constructive type of form and in the working economy of the engines.

By reference to the table (section F), it appears, under the special conditions of service under consideration, that by the size of the ship being reduced from 5000 tons displacement to 3000 tons displacement, combined with an inferior type of form, as indicated by the coefficient of performance being reduced from 250 to 150, and an inferior construction of engine, as indicated by the consumption of coals being increased from 2 lb. to 4 lb. per indicated horse-power per hour, the expense or freight charge per ton of goods conveyed becomes increased in the ratio of 49 to 113, that is, in the ratio of 100 to 230, being an increase of 130 per cent.; or, assuming the freight by the standard ship A of 5000 tons, of which the coefficient of performance is 250, and the consumption of coal at the rate of 2 lb. per indicated horse-power per hour, to be at the rate of £1 per ton of goods conveyed, the rate of freight by ship F of 4000 tons, of which the coefficient of performance is 200, and the consumption of coal at the rate of 3 lb. per indicated horse-power per hour, will be £1. 5*s.* 2*d.*, being an increase of 26 per cent., and by ship F_2 of 3000 tons displacement, of which the coefficient of performance is 150, and the consumption of coal at the rate of 4 lb. per indicated horse-power per hour, the rate of freight becomes £2. 6*s.*, being an increase of 130 per cent. per ton of goods conveyed under the conditions referred to.

The comparative freight charges on 100,000 tons of goods by the vessels A, F_1, F_2, respectively, would be £100,000, £126,000, and £230,000.

Section G.—Freight as affected (*cæteris paribus*) by variations of the steaming speed at which it is required that the service shall be performed.

It is proposed to illustrate this most important elemental consideration by reference to rates of speed within the range of present practice—namely, from 10 to 14 knots per hour.

By reference to the table (section G), it appears that, under the special conditions of the service under consideration, by increasing the speed from 10 to 12 knots per hour, the expense or required rate of freight per ton of goods conveyed becomes increased in the ratio of 49 to 64, that is, in the ratio of 100 to 131, being an increase of 31 per cent.; and by increasing the speed from 10 to 14 knots, the expense or required rate of freight per ton of goods becomes increased in the ratio of 49 to 93, that is in the ratio of 100 to 182, being an increase of 82 per cent. Hence, assuming the freight by the standard ship A of 5000 tons, making a passage of 3000 nautical miles at 10 knots per hour, to be at the rate of £1 per ton weight of goods conveyed, the rate of freight by ship G_1, steaming at 12 knots per hour, will be required to be £1. 6*s.* 2*d.* per ton weight of goods conveyed; and the rate of freight by ship G_2, steaming at 14 knots per hour, will be required to be £1. 16*s.* 5*d.* per ton of goods conveyed. The comparative freight charges on 100,000 tons of goods by the vessels A, G_1, G_2, steaming at 10, 12, and 14 knots per hour, respectively, would be £100,000, £131,000, and £182,000.

Hence we see how onerous are the obligations which usually impose on mail packets a rate of speed higher than that which would be adopted for prosecuting a purely mercantile service; and as no service can be permanently and satisfactorily performed which does not pay, it follows that the inadequacy, if any, of a high-speed postal subsidy must be made up by surcharge on passengers and cargo, and is therefore, *pro tanto*, a tax upon trade.

Section H.—Freight as affected (*cæteris paribus*) by variations of the size of ships combined with variations of steaming speed.

We will suppose the size of ships to be 5000, 4000, and 3000 tons displacement, and the steaming speed to be at the rate of 10 knots, 12 knots, and 14 knots per hour, respectively.

Freight as affected by Differences in the Dynamic Properties of Steam Ships.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Reference.	Designation of vessels.	Constructor's load displacement.	Steaming speed per hour.	Coefficient of performance.	Coal per indicated horse-power per hour.	Coefficient of economic duty.	Power.	Passage.	Weight of hull and its equipment complete.	Weight of engines and their equipment.	Weight of coal for the passage.	Weight of cargo.	Investment in hull at £50 per ton weight.	Investment in engines at £15 per indicated horse-power.	Total investment.	Comparative rates of expenses incurred per ton of cargo.	Comparative ratios with reference to freight by ship A, taken at 100.	Comparative rates, with reference to freight by ship A at £1 per ton weight.	Comparative freight charges on 100,000 tons of goods.	Designation of vessels.
Section.		Tons.	Knots.	$\frac{V^3D^{\frac{2}{3}}}{\text{I.H.P.}}$	℔	$\frac{V^3D^{\frac{2}{3}}}{W}$	I.H.P.	N.miles.	Tons.	Tons.	Tons.	Tons.	£	£	£	$\frac{\text{Investment}}{\text{Cargo.}}$	Ratios.	£ s. d.	£	
A	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	A_1	4000	10	250	2	14000	1008	3000	1600	252	270	1878	80000	15120	95120	51	104	1 0 10	104000	A_1
	A_2	3000	10	250	2	14000	832	3000	1200	208	223	1369	60000	12480	72480	53	108	1 1 8	108000	A_2
B	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	B_1	5000	10	200	2	11200	1462	3000	2000	365	392	2243	100000	21930	121930	54	110	1 2 0	110000	B_1
	B_2	5000	10	150	2	8400	1950	3000	2000	487	522	1991	100000	29250	129250	65	132	1 6 5	132000	B_2
C	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	C_1	5000	10	250	3	9333	1170	3000	2000	292	470	2238	100000	17550	117550	52	106	1 1 2	106000	C_1
	C_2	5000	10	250	4	7000	1170	3000	2000	292	627	2081	100000	17550	117550	56	114	1 2 10	114000	C_2
D	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	D_1	5000	10	250	2	14000	1170	3000	2500	292	313	1895	125000	17550	142550	75	153	1 10 7	153000	D_1
	D_2	5000	10	250	2	14000	1170	3000	3000	292	313	1395	150000	17550	167550	120	245	2 9 0	245000	D_2
E	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	E_1	5000	10	200	3	7467	1462	3000	2000	365	588	2047	100000	21930	121930	59	120	1 4 0	120000	E_1
	E_2	5000	10	150	4	4200	1950	3000	2000	484	1044	1472	100000	29250	129250	88	179	1 15 10	179000	E_2
F	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	F_1	4000	10	200	3	7467	1260	3000	1600	315	506	1579	80000	18900	98900	62	126	1 5 2	126000	F_1
	F_2	3000	10	150	4	4200	1386	3000	1200	346	742	712	60000	20790	80790	113	230	2 6 0	230000	F_2
G	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	G_1	5000	12	250	2	14000	2021	3000	2000	505	451	2044	100000	30315	130315	64	131	1 6 2	131000	G_1
	G_2	5000	14	250	2	14000	3209	3000	2000	802	614	1584	100000	48135	148135	93	182	1 16 5	182000	G_2
H	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	H_1	4000	12	250	2	14000	1702	3000	1600	425	380	1595	80000	25530	105530	66	134	1 6 10	134000	H_1
	H_2	3000	14	250	2	14000	2283	3000	1200	571	437	792	60000	34245	94245	119	243	2 8 7	243000	H_2
I	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	I_1	5000	12	250	3	9333	2021	3000	2000	505	677	1818	100000	30315	130315	72	147	1 9 5	147000	I_1
	I_2	5000	14	250	4	7000	3209	3000	2000	802	1228	970	100000	48135	148135	152	310	3 2 0	310000	I_2
K	A	5000	10	250	2	14000	1170	3000	2000	292	313	2395	100000	17550	117550	49	100	1 0 0	100000	A
	K_1	5000	12	225	3	8333	2245	3000	2250	561	751	1438	112500	33675	146175	102	208	2 1 8	208000	K_1
	K_2	5000	14	200	4	5600	4012	3000	2500	1003	1535	0	...	...	...	...	...	..	...	K_2

By reference to the table (section H), it appears that, under the special conditions of the service under consideration, by reducing the size of the ship from 5000 to 4000 tons, and increasing the speed from 10 to 12 knots per hour, the expense or required freight charge becomes increased in the ratio of 49 to 66, that is, in the ratio of 100 to 134, or 34 per cent.; and by reducing the size of ship from 5000 to 3000 tons, and increasing the speed from 10 knots to 14 knots, the required freight charge becomes increased in the ratio of 49 to 119, that is, in the ratio of 100 to 243, being an increase of 143 per cent., or a multiple of 2½ times nearly. Hence, assuming the rate of freight by the standard ship A of 5000 tons, steaming at 10 knots per hour, to be at £1 per ton weight of goods conveyed, the required rate of freight by ship H_1, of 4000 tons, steaming at 12 knots, will be £1. 6*s*. 10*d*.; and the required rate of freight charge by ship H_2, steaming at 14 knots per hour, will be at the rate of £2. 8*s*. 7*d*. per ton weight of goods conveyed.

The comparative freight charges on 100,000 tons of goods by the vessels A, H_1, H_2, respectively, will be £100,000, £134,000, and £243,000.

SECTION I.—Freight as affected by variations of speed combined with variations of the working economy of the engines.

Assuming the rate of speed to be 10 knots, 12 knots, and 14 knots, and the consumption of coal to be 2 lb., 3 lb., and 4 lb. per indicated horse-power per hour respectively, by reference to the table (section I.), it appears that by increasing the speed from 10 knots to 12 knots an hour, and the rate of consumption of coal being also increased from 2 lb. to 3 lb. per indicated horse-power per hour, the required freight charge becomes increased in the ratio of 49 to 72, that is, in the ratio of 100 to 147, or 47 per cent.; and by increasing the speed from 10 knots to 14 knots per hour, and the rate of consumption of coal being also increased from 2 lb. to 4 lb. per indicated horse-power per hour, the required freight charge becomes increased n the ratio of 49 to 152, that is, in the ratio of 100 to 310, being an increase of 210 per cent., or more than trebled. Hence, assuming the expense or required freight charge by the standard ship A, steaming at 10 knots per hour, and consuming 2 lb. of coals per indicated horse-power per hour, to be at the rate of £1 per ton of goods conveyed, the required freight charge by ship I_1, steaming at 12 knots an hour and consuming 3 lb. of coal per indicated horse-power per hour, will be at the rate of £1. 9*s*. 5*d*. per ton of goods, and the required freight charge by ship I_2, steaming at 14 knots per hour, and consuming 4 lb. of coal per indicated horse-power per hour, will be at the rate of £3. 2*s*. per ton of goods conveyed. The comparative freight charges on 100,000 tons of goods by the vessels A, I_1, I_2, respectively, would be £100,000, £147,000, and £310,000.

Hence we see how onerous are the obligations of increased speed, if attempted to be performed with engines of inferior construction as respects economy of fuel.

SECTION K.—Freight as affected (*cæteris paribus*) by variations of the speed combined with variations in the type of form, working economy of the engines, and weight of hull.

The object of this section is to show the effect, even of small differences of practical construction, when operating collectively to the detriment of a ship, combined with the obligation of increased speed.

By reference to the table (section K) it appears that under the special conditions of the service under consideration, by increasing the speed from 10 to 12 knots, with a ship of inferior type of form, as indicated by the coefficient of performance being reduced from 250 to 225, and of inferior engine arrangement, as indicated by the consumption of fuel being increased from 2 lb. to 3 lb. per indicated horse-power per hour, the weight of hull being also increased 5 per cent.—namely, from 40 per cent. to 45 per cent. of the constructor's load displacement; by this combination the expense per ton of goods conveyed becomes increased in the proportion of 49 to 102, that is in the proportion of 100 to 208, being an increase of 108 per cent., or more than doubled; or, assuming the freight by the standard ship A to be at the rate of £1 per ton, the rate of freight by ship K_1, under the differences above referred to, becomes £2. 1*s*. 8*d*.; and it is to be observed that if the speed be increased to 14 knots, whilst at the same time the coefficient of performance is reduced to 200, the consumption of fuel increased from 2 to 4 lb. per indicated horse-power per hour, and the weight of the hull increased 10 per cent.—namely, from 40 per cent. of the load displacement to 50 per cent.; under these conditions the entire load displacement of the ship K_2 will be appropriated by the weight of the hull, engines, and coal, leaving no displacement whatever available for cargo; that is to say, the vessel K_2 is utterly unable to perform the conditions of the service as a mercantile steamer.

The comparative freight charges on 100,000 tons of goods by the vessels A and K_1 respectively would be £100,000 and £208,000.

As respects the relation which subsists between the dynamic properties of vessel A, taken as the standard of comparison in the foregoing sections, and the dynamic properties of mercantile steam ships generally at the present time, it might be regarded as invidious to refer to and particularise the actual performances of vessels presently employed on commercial service, but it may be affirmed generally that the ocean performance of mercantile steam fleets does not average a coefficient of economic duty by the formula $\frac{V^3 D^{\frac{2}{3}}}{W}$ exceeding 5600, whilst modern naval architecture and engineering has practically shown that with certain types of form the coefficient of performance may be expected to vary from 250 to 300, and that some engines of modern construction have consumed only from 2 lb. to 2½ lb. of coal per indicated horse-power per hour, thus practically constituting a possible coefficient of economic duty as high as 14,000, which has therefore been assigned to ship A in the foregoing table, and whereby, under the conditions of the service referred to—viz. ships of 5000 tons displacement steaming at 10 knots per hour on a passage of 3000 miles, the conveyance of goods per ton weight may be expected to be performed at fully 30 per cent. less cost than would be necessarily incurred under the same circumstances by vessels of the same size, but of which the coefficient of economic duty does not exceed 5600; and this comparative difference would be greatly exceeded if the size of ships be reduced, the length of passage increased, or the speed accelerated.

From the foregoing statements it appears that public interests in the great matter of FREIGHT demand that steam ships only of the most effective construction, as respects hull and engines, be employed on mercantile service. Bad types of hull and wasteful engines necessarily, as we have seen, enhance freight, increase the cost of production, and consequently curtail consumption, thus constituting a blight on national industry. A check on these evils, highly conducive to the gradual reduction of freight expenses by steam ships, would at once be instituted by making it a matter of *contract stipulation*, that a definite coefficient of DYNAMIC DUTY by the formula $\frac{V^3 D^{\frac{2}{3}}}{W}$ should be realised on test trial of the ship, at the builder's load displacement and steaming at the stipulated speed. Unquestionably for years past, in our popular marine engineering, prejudice and expediency have retarded progress; marine engineering practice has not duly availed itself of the established truths and science of the times. Expansion, superheating, and surface condensation, now being reanimated as the basis of modern improvements, are but the legacies of a by-gone age hitherto neglected.

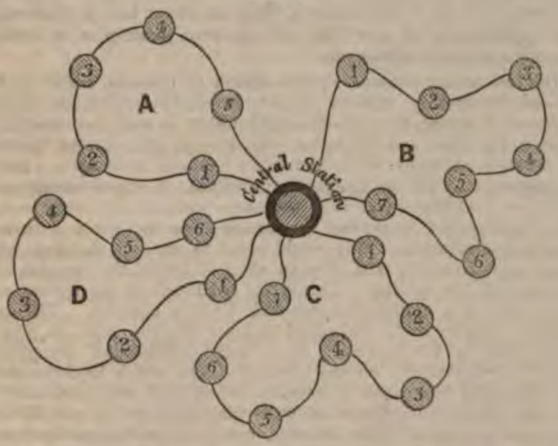
It is only by directing public opinion to bear on such subjects of general interest, that any prevalent evil can be corrected; and surely an appeal on the important subject of FREIGHT, as affected by differences in the dynamic properties of steam ships, cannot be more appropriately made to any public body than to the British Association, under the presidency of a man especially distinguished and honoured in the path of practical science, and assembled at Manchester, the birthplace of free trade, and the manufacturing capital of the world.

On Fire and Railway Alarms. By C. W. SIEMENS.

In the years 1849 and 1850 the firm of Siemens and Halske applied electricity to the two important purposes of giving immediate information of the locality where a fire breaks out, and of announcing the progress of every railway train from station to station, so as to be known by every engine-driver, pointsman, and platelayer along the section of the line where the train is to pass. Both these systems have now stood the test of nearly twelve years' trial on a very extensive scale, but, having never been brought prominently before the British public, their application has remained confined to Germany, and other continental countries. The calamities caused lately, both by the several extensive conflagrations and railway collisions, render this perhaps the most favorable opportunity of bringing the subject forward.

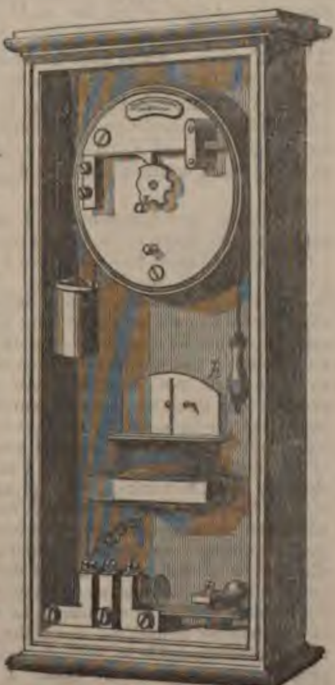
The Fire Alarm Telegraph was first established at Berlin, in 1849, but has since been adopted in other cities.. The city is divided into a number of fire districts, comprising each a suitable number of alarm and engine stations, connected by underground line-wire. Each district forms an independent circuit, and is distinguished by a letter of the alphabet, while the single stations in the same are marked by consecutive numbers; the line wire of each circle passes through a central station. (See Fig. 1.)

Fig. 1.



Supposing a fire breaks out in district B, near station 5; the person who first observes it proceeds to the near station, (usually the post-office, theatre, or engine station), where an alarm apparatus (Fig. 2) is exposed to view. In breaking the glass window of the casing, and pulling the handle *h*, the disk *d* is set in motion by clockwork, and the galvanic circuit in district B is interrupted and restored a certain number of times, and a bell placed in the alarm case at each engine station of the district is sounded correspondingly. After a short pause this signal is repeated, by action of the clockwork, and again a third and fourth time, in order to give ample opportunity to the watchman at the engine station to notice not only the fact that a fire has broken out in his district, but also the station whence the alarm proceeds. The engines of the district will thereupon at once proceed to the position indicated by the signal. At the central station the same acoustic signal is received, but in addition to that the central station receives unmistakable information of the district where the alarm has been given, by the release of a lever bearing the letter B, or other number denoting the circuit. The chief superintendent stationed at the central station can thereupon communicate to and receive information by ordinary Morse signals from the station where the alarm was given, respecting the extent of the fire, &c., and, if it appears necessary, he has it in his power to communicate the alarm to as many of the other circles as he may find necessary, and to communicate to them particular instructions. The whole system is worked by a single battery placed at the central station, the communications being made by interrupting the metallic circuit.

Fig. 2.

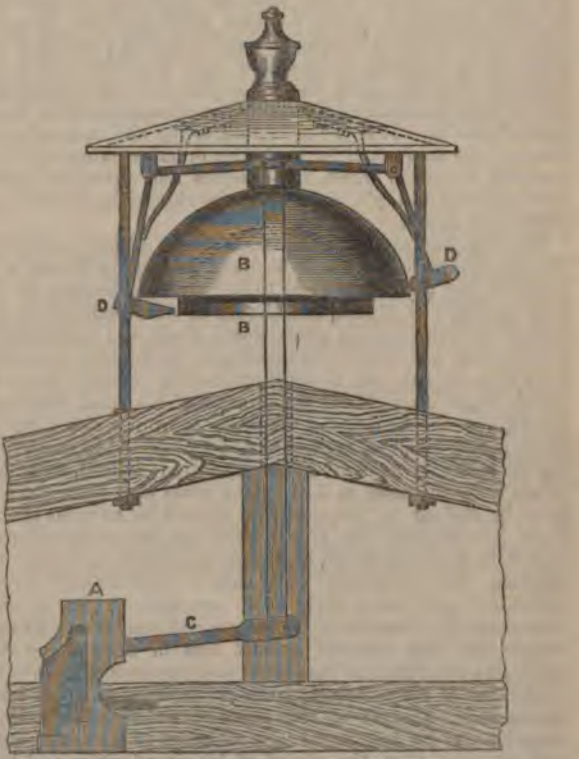


This system has not been known to fail since its introduction, and it is certainly a remarkable fact, that there has been no great fire at Berlin ever since its introduction; five minutes being generally sufficient to bring the first engine to the scene of action after the alarm is given.

The Railway Alarms which are at present in general use in Germany, consist of one or two cast-iron bells placed on the top of the signalman's hut or elsewhere along the line, at intervals from a quarter to half a mile, all of which are connected by a single line-wire between station and station. At each station a battery, or more recently a powerful multiple magneto-electric apparatus, is placed, and in turning the handle of this machine, a series of powerful currents is sent through the line-wire, which releases the clockworks of all the alarms between the two stations. Their bells will then give the signal all along this section that a train has just left the station, and continue to sound for a sufficient length of time to be distinctly heard at every point of the line, including the next station. A difference is made between the up and down trains; in announcing the one by giving the signal only once, and the other by repeating it after a short interval.

By placing in the circuit at each of the stations one of Siemens and Halske's magneto-electric dial apparatus, and connecting the line-wire at each of the alarm stations by an iron bar, capable of being removed when necessary, the engine driver will be able to communicate with the stations from any point of the line, in case any accident should happen to the train, simply by inserting the magnet electric dial instrument which he carries constantly on his engine, into the line in place of the iron bar of the nearest alarm hut, signalling and receiving in the usual way. This alarm apparatus would render accidents such as have lately happened almost impossible; and it is well known that accidents of that description are hardly known in Germany, where this system has been generally introduced.

Fig 3.



Fig, 3, shows the general arrangements of the railway alarum. A, is the electro-magnet with the clockwork, generally protected by a wooden case. BB, are two bells of different sounds, under an iron roof on the top of the the station house. CC, the arms which move the hammers DD.

(The report of the Sections will be continued in our next.)

REVIEWS.

Recollections of A. W. Pugin. By BENJAMIN FERREY, Architect, F.R.I.B.A.—London: Stanford. 1861.

A life of Welby Pugin has certainly yet to be written—at least, regarded from a professional point of view. The 'Recollections' of Mr. Ferrey are without doubt valuable contributions to the more general and personal phase of it, but they cannot be said to satisfy an inquirer wholly, or in the manner necessary, viewing Pugin as the reforming architect he claims, and which all must allow him to have been. Generalities or recapitulations simply of every-day acts, however extraordinary, never do satisfy in the case of such a man: while panegyric should be based upon a foundation laid open to the observation of all who look to see and judge whether such be deserved or is concluded by a practical result. It has been already well observed by a contemporary that Mr. Ferrey, desiring for Mr. Pugin a rank among the most eminent architects of the present or former days, does not dwell upon one single proof of the supremacy in stone and brick which he says generally was his due. There will be few of those indeed, among his professional brethren more particularly, who will deny to Pugin the credit justly belonging to him of being the strenuous and enthusiastic supporter, both in theory and in his literary productions, of the true and legitimate in architecture, as distinguished from the common practice of his time, or who will fail to attribute to him, as a prime mover through the influences of his uncompromising pen and powerful pencil, a very large share of the good which has followed his strictures upon the debased and untruthful expression characteristic of the buildings of his day. It is the more interesting and imperative therefore on this account, if for no better or more extended a reason, that the extent to which his theories and advocated principles were embodied in his material works should be shown as far as possible in any review of his life.

The data and opportunities for arriving at any certain conclusion on this point are not to be found among Mr. Ferrey's 'Recollections;' and this is the more to be regretted, because Mr. Ferrey is an architect of repute, and should be well qualified by the particular direction of his professional study and acquirements to discriminate and instruct in relation to the subject. It would perhaps be a difficult task to point out how far, clearly, the buildings which Pugin erected bear the impress of his mind, unfettered by extraneous interference and the pressure from without which it is the common lot of all architects to be subjected to, notwithstanding they be ever so bold in denunciation; indeed, from his own words it would seem as if in many cases they were not so much what he desired or proposed they should be, as what the restrictions surrounding him necessitated (see the observations he is stated to have made on St. George's Church, and those at Nottingham and Kirkham); still, such a task should have been attempted, and particularly by an architect writing of an architect—even if it were only for the sake of answering the reproach which has been levelled against him of acquiescing "in the miserable conditions of cheapness and parsimony." Instead of a simple list of his buildings, a critical analysis of them, with references to the amount of true principle exhibited in them, would have been of far greater value as a feature in his architectural life and progress, than the record of his singularities and his rudenesses, however far either of the latter may have insured his notoriety or originated his "utter contempt for effeminacy and dandyism."

The same observation applies also to the account of his matrimonial disappointment, in which the "statement of facts" stands so prominently as a feature. Little general and scant professional interest can possibly attach to this curious episode in Pugin's career; and, except as showing the natural enthusiasm and religious prejudice actuating all he did, can be but of little moment to any but his family, and the other parties more immediately concerned.

Again, how closely stands the relationship, agreeably to the old proverb, between the sublime and ridiculous, is very unnecessarily presented in the case of the wedding card used on his third and last marriage. This, and the letter of congratulation from Lord Shrewsbury, add no halo to the name or memory of Pugin. The former is puerile altogether, and the latter simply a kind and opportune testimony of personal consideration, giving no higher title to the position of the recipient, architecturally speaking, than that which his acknowledged talent had already fixed upon him—a reflection borrowed from the friendly courtesies of high rank is quite unnecessary to Pugin's professional fame.

The absence from the 'Recollections' of the more critical review of Pugin's productions and professional life here adverted to, several of the notices which have appeared of Mr. Ferrey's work have sought to supply, at least in some part. In one of these—the *Saturday Review*—the reviewer, having dilated on his theory, says that, "as to the practice of his art we should judge him by his actual works to his disadvantage;" admitting, however, it to be "well known, that he never had a thoroughly good opportunity of carrying out his own principles of design." In continuation he observes—

> "His best works, perhaps, are the church at Cheadle, which he built for Lord Shrewsbury, and the church in St. George's-fields, London, The former however, though a beautiful design, is over decorated in proportion to its scale; and the latter, with several grave faults, has never been finished externally, while its interior has been fitted up in a manner quite opposed to all its designer's principles of church arrangement. Both these buildings—and it is the same with all his other works—show Pugin's chief weakness: the design is on too great a scale for the actual dimensions. We could point to modern churches which, though insignificant in area, give an effect of height and breadth which approaches to the sublime. This is the touchstone of the highest architectural art: it is quite otherwise with Pugin's churches. The actual structures require to be magnified at least fifty per cent. to give the proper effect to the design. As a mere architectural draughtsman Pugin was unrivalled, but the glorious visions which he delineated on paper dwindled into mean proportions when they were translated into brick and mortar. No doubt this was owing partly to his peculiar training as a scene-painter for the theatres; but he never forgave the friendly criticism which pointed out the difference between the promise and the performance of his designs. Anyone may test for himself our present criticism of his style of drawing who will try with a pair of compasses the very beautiful perspective of the St. George's-fields Church, as originally proposed by Pugin, which adorns this volume. Allowing the moderate tallness of 5 ft. 8 in. for the priest at mass, the height of the central boss of the apse groining will be more than 75 feet from the raised steps of the altar. So that, we repeat, the genius of Pugin will not be fairly judged by the actual buildings which he has left behind—unless indeed by the unpretending, and therefore much more satisfactory little church, which he built at his own cost, adjoining his own house, on the West Cliff at Ramsgate."

There is a considerable amount of truth in these observations; on the other hand, as showing how commonly the restraining subjection to which we have before alluded, and which he himself directly complains was exercised in the cases mentioned, had to be contended against, and how fatally it may have been applied in others where favouring circumstances existed in less degree than they did in that which we shall now bring forward, an instance occurs in connection with the alterations effected by Pugin at Alton Towers. Even here he had to combat for correctness and the proper expression of his idea, though ultimately in this case he met with more fortune in the way of success than it is probable he could on all occasions command. Writing in answer to some expressed wish of Lord Shrewsbury, to retain portions of the existing work condemned by Pugin, the latter says as follows:—

> "Hornby Castle.
>
> "My dear Lord Shrewsbury,—I cannot admit that I am to blame respecting the design of the dining-room. Of course, I intended to make a fine thing, suitable to the purpose for which it is destined, and not a common room, fit only for an hotel. This is the very first room at the Towers that I was called upon to design, and it was quite natural that I should wish to produce something that would have a striking effect, especially when so many persons were loud in condemning the alterations, and declaring that the present room was far better than anything that could be done: yes, indeed, on the plan proposed by your lordship at present, I do think the present room *far better* as regards design; for the new room would be the most commonplace apartment that can well be imagined. If I am not enabled to exercise any judgment, and make use of my knowledge and experience, I am reduced to the condition of a mere drawing clerk, to work out what I am ordered, and this I cannot bear; and, so far from knocking under, I really must decline undertaking the alteration unless your lordship will consent to its being made worthy of your dignity and residence. It shall never be said that I have spoilt the dining-room at Alton: I would not do it for a thousand pounds. I always opposed the window; and at one time your lordship suggested it would do for the east window of a church, to which I quite agreed, for it is a church window in design. From the first moment I spoke of a screen; and it is indispensable to break the current of air into the room. I never proposed anything for *mere effect*. I know my design was quite right, and again I entreat of your lordship to carry it out, or to leave the present building unaltered. . . Nothing can be more dangerous than looking at prints of buildings, or trying to imitate bits of them; these architectural

> books are as bad as the Scriptures in the hands of Protestants. I am very unhappy about it; and as regards the hall, I have nailed my colors to the mast,—a bay window, high open roof, lantern, two good fire-places, a great side-board, screen, minstrel-gallery—*all or none.* I will not sell myself to do a wretched thing. Lady Shrewsbury told me, when I was last at Alton, that she would rather see the present room left, unless the new one was a truly fine work; and I am sure her ladyship is right.
>
> Ever, dear Lord Shrewsbury, &c.,
>
> A. WELBY PUGIN."

In relation to this view of the matter Mr. Ferrey very properly brings forward this letter of Pugin, as an instance of "the independent manner in which he insisted upon carrying out his own views" wherever possible, and as illustration of the fond hope he had entertained that "in designing buildings for his lordship he should be spared the mortifying interference so often encountered with public committees, and been permitted to erect structures in every respect suitable to the dignity of his employer." Where he was enabled to do this the results are generally satisfactory. The church at Cheadle is certainly one of the best of the works erected by him strictly in the way of his profession, but the unpretending hospital of St. John, at Alton, claims an almost equal share in the list; there is also a church at Yarmouth hardly less deserving of attention, as exhibiting the old principle and character he so earnestly contended for. Others are more open to the charge just made of weakness and poverty in constructive fact and effect. In Birmingham and Derby are notable examples, but these are among his first efforts, and may have been also affected by the causes we have referred to; one great and redeeming quality in all defects however is the reality in his work, which he ever retained and fought for, and the previous general absence of which he was among the first to depreciate and expose. He it was, as has been truly observed by a late writer, who first publicly contrasted "the shams and concealments of modern architecture with the heartiness and sincerity of Mediæval work;" and showing "the fair outside of a modern building having no relation to its construction, except that of a screen to hide its faults," exhibited in opposition to it that "the first principle of Mediæval work was to expose construction, and not to hide it, but to adorn it." "A modern building for example," in continuation the same writer observes, "conceals its flying buttresses with a dead wall; an ancient one exposes them, and derives a principal charm from these contrivances being seen. It is the law of all the old architecture,—there is nothing it fears to show, it rather invites inspection within and without; whereas concealment was for long the rule of modern British architecture—concealment of the real materials—concealment of the manner of contruction." Let us remember, to Pugin's honour he adds: "that if now there seems to be the dawn of a better architecture, if our edifices seem to be more correct in taste, more genuine in material, more honest in construction, and more sure to last, it was he who first showed us that our architecture offended not only against the laws of beauty, but also against the laws of morality."

No higher or more just tribute can be paid to Pugin than this, and it is one with which his warmest admirer should be satisfied, since few will fail to indorse it as representing the true view and colour of his primary and distinguishing excellence, and as showing the grand point in relation to his art, to which all his after efforts tended, and with greater or less amount of positive success attained to.

With reference to the religious sentiments and prejudice of Pugin in connection with his theory and inculcation, Mr. Ferrey deals very fairly and truthfully. Vindicating Pugin from the imputation of being led to his change of religion "*solely* by the love he had for the outward splendour of the middle ages;" he states that "this was far from being the fact," and claims for him a rest for his faith "on far higher grounds than his admiration for external magnificence." On the other hand, speaking of 'Contrasts,' he refers to the unquestionable unfairness of his selections, induced "by his desire to put everything connected with Protestantism in a bad light." "Moderation in most matters," he says, "was unknown to him; and it is not likely he would have practised that virtue when dealing with the system of the church from which he had just seceded;" and he gives in illustration the following passage from that work, than which nothing, as he truly observes, can be more "exaggerated" in character.

> "When we reflect on the horrible repairs, alterations, and demolitions that have taken place in our venerable edifices, ever directed by a tepid and parsimonious clergy, brutal and jobbing parochial authorities, and ignorant and tasteless operatives, I do not hesitate to say that the lover of ancient art has more to regret during the period the present establishment has had the churches in possession than even during the period that drove the ancient churchmen from them."

Of a parallel kind are the feelings expressed in what Mr. Ferrey denominates truly the "one great fallacy in the remarks made in his 'Contrasts,'" the object of which is to prove "that no work of high art can be produced by anyone not within the pale of the Roman Church." "This," says Mr. Ferry, "is the whole gist of Pugin's arguments."

> "He appears wholly insensible of the merit which belongs to work of the Classic period, and we find not a word even in toleration of that great school of art. Conceding very readily the unsuitableness of the severe Greek and Roman styles of architecture for giving the most impressive character to religious edifices; still the assertion that it is impossible to effect great and masterly productions unless inspired by the genius of the Roman Catholic Church, is untenable. No one denies that the ceremonial character of the ritual of that church, and the intensity of feeling generated by its doctrines and traditions, afforded a wide scope for the exercise of those branches of art, such as architecture and painting, which have flourished chiefly in connection with it; nor that a revulsion of feeling, not yet wholly extinct, which took place at the Reformation, chiefly through the fanaticism of the Puritans, affected most seriously the cultivation of fine art. Still, to conclude that none but Roman Catholic artists can produce works of merit and feeling, even in a religious sense, is a lamentable mistake, of which Pugin himself must have been convinced before his death. Beyond all doubt a debt of gratitude is due to him for the remarks in his 'Contrasts,' calling attention to the degraded state of architecture; but the public fail to recognise that identity of cause and effect, which, in Pugin's view, would give the monoply of art to the Church of Rome. The many structures erected by Pugin himself, though superior to the generality of modern buildings, and exhibiting much of the architectural truthfulness for which he contended, are yet far from being perfect; on the other hand, several churches and schools in connection with the Anglican communion have been built since he commenced practice, which beyond all question, both in design and feeling, will bear comparison with anything executed by him. Nay, more, they may be considered superior, since they manifest an amount of study and care in design which are sometimes found wanting in Pugin's best works. The very soul and expression which he claims as exclusive prerogatives of his own church, are present in the carefully considered details of some of our own recently built churches. But in justice to Pugin, it should be added that this excellence has been really attained through the impetus which his writings gave to the study of 'the true principles of Gothic architecture.'"

The prejudices exhibited in the limited views which Mr. Ferrey thus remarks upon, are the disparaging features in Pugin's character, the more so as he was on occasion quite alive to the incorrectness of them, as is proved by his own observation recorded in a later part of Mr. Ferrey's work, where it is stated that "speaking to a friend, he observed 'that the only merit he claimed was giving to other architects the *key* to the use of the knowledge which they in theory already possessed; that since he opened the door other men had surpassed him in the goodness of their work.'"

However far, nevertheless, this perversion of his mind may have existed, we must not shut our eyes to his real merit in an artistic point of view, and as the great advocate and promoter of the great good that his forcible and unsparing observations have called forth. That we owe largely to him in this respect is unanimously allowed. Mr. Ferrey not more justly than prominently brings this forward, and his observations have received the stamp of general echo and acquiescence. One writer says:—"That though his works may be much open to criticism, and the leading idea of his life be an exceedingly subordinate one in the life of the world, yet there can be no doubt that the strong earnestness of his devotion to that one idea enabled him to set his mark for ever in the history of art in England." Another say:—"The merits of Pugin we hold to have been real. If he was wild, he was honest. He had the true artist-sense, the true artist-eye, the true artist-hand, the true artist-heart. But mental distemperature may have set in with him at an early age; and such fact may offer the key to much that is violent and without coherence in his career." It is probable that this was really the case:—"eager, excitable, impressionable, and impulsive," as a third writer remarks, he was just the subject to offer open ground to the seed of such disease, and it will be no more than due charity to conclude that the illiberality of doctrine he generally exhibited in dealing with the religious view of his art, is owing to such infliction, and a consequent partial affection and abasement of his mental powers.

In completion of Mr. Ferrey's book an appendix has been added, having for its burden the consideration of Pugin's writings and character in their Catholic aspect. The arguments adduced in support of, and the success in relation to its object attained by the writer of this portion of the work, has been already so fully discoursed upon, and so fairly disposed of, in almost every notice which has appeared of the book, that it is unnecessary here to enlarge upon it. It may be sufficient to say that they are disappointing; and, as one literary opinion gives it, seeking "to show that Pugin was less tolerant than his actions and writings showed him to be, happily for Pugin's fame do not prove the point" argued for. Pugin was doubtless sectarian in a large degree—but his better nature was not always dormant, and he lived, it is generally admitted by those who knew him best, to discover and allow the existence at last of some good from out of Galilee.

A Complete Treatise on Cast and Wrought Iron Bridge Construction. By William Humber, A. Inst. C.E., M. Inst. M.E. Folio, 2 vols. (text and plates.)—London: Spon.

Having briefly noticed this work in our last number, we purpose now bestowing some further examination on the text.

In the first or theoretical part it is evidently sought to exhaust the subject of the strains, sectional strength, and deflection of girders, and some attention is also given to the arch and the chain.

On transverse strain and moment of inertia, detached and continuous girders, &c., we have in these pages a pretty fair compendium of what mathematical research has effected up to the present time. We regret to observe some inaccuracies in the printing of the algebraical portions, which a careful revision should have excluded from a work of such considerable pretensions, but otherwise, the treatment appears (on a somewat cursory inspection) satisfactory, and in accordance with existing standard authorities.

Following however, as he has wisely done, the beaten track in these investigations, the author is apparently not without suspicion that a more direct method of getting at the strains caused by the load might be desired, or even attempted, by some.

> "It will doubtless be remarked, that in treating the case of a straight girder generally I do not commence at the load itself, and immediately show its results upon that part of the structure with which it is in contact, although as all strains must pass through such parts to the piers, it would seem most natural so to do; but on the contrary, I calculate the effects of the loads placed upon the structure, from the reaction of, or effect produced upon, the points of support. To treat the subject in a different way may or may not be possible; but I did not attempt it, feeling that the introduction of methods of reasoning totally different to those which have already been received would be very undesirable in a work pretending to a practical character, and intended for reference; but I notwithstanding thought it equally undesirable to pass unnoticed so important a point, wherefore I have introduced into the sixth chapter, which is devoted to the consideration of shearing strains, an investigation of the immediate relations existing between the downward pressure of the load on a beam, and the direct strain on the horizontal fibres of such beam; but I have there limited myself to the determination of the mode in which the vertical force produces horizontal strain, without at all inquiring into the numerical relations of the two forces."

When we turn, however, to the chapter spoken of, we find anything but a lucid exhibition of the manner in which the horizontal compressive and extensive strains are generated. Why the upper part of a beam supported at both ends sustains compression and the lower part extension, and why these conditions are reversed in the case of a beam supported at one end only, it would be difficult to gather from following Mr. Humber's explanation.

> "If the beam was fixed at one end, and free at the other, the particles in the upper parts of the sections would be most readily movable, and would, therefore, be separated to a greater distance than those in the lower part of the beam; hence, supposing them to revolve, while their relative position is being altered, round an axis contained within the beam, the upper part will be in tension and the lower in compression."

We fail to derive any clear idea from the sentence we have just quoted. Why the upper parts should be most readily movable, and why their higher mobility should cause them to be in tension and the lower parts in compression, our author does not tell us.

In treating of straight detached girders the following formula is given for the variable greatest strain under a concentrated movable load:—

$$M = -\frac{W(l-x)}{l} \cdot x,$$

where l is the span, and x the distance of the load W from one end of the girder. This of course is correct, which is more than can be said for the following inference:—

> "The curve of moments for a moving load which may be calculated by this formula will be elliptical."

The formula is readily reducible to the following form:—

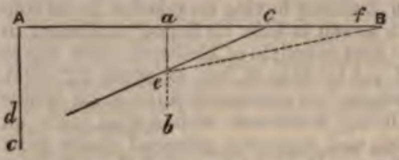
$$M = -\frac{W}{l}\left(\frac{l^2}{4} - x^2\right)$$

x being the distance of the load from the half-span. It is therefore very obvious that the curve of moments in question is not an ellipse, but a parabola.

The "theory of arches and bowstring girders" is treated in a somewhat summary manner. The formulæ arrived at are sufficiently clear, but applicable only to the case of a load disposed on a roadway above the arch rib, with spandrels effectually braced. We do not find any rule specially suited to the bowstring girder carrying the load on a level with the tie, although the heading of the chapter leads us to look for it. We are informed at the outset that "investigations into the conditions of equilibrium of linear arches" are no longer regarded in the construction of arches of metal. Yet further on in the chapter the "line of pressures" is spoken of, which is essentially a part of the theory previously said to be discarded.

In examining the form of the line of pressure for an equally distributed load, the author produces a well-known and correct result indeed, but seeks to prove it by reasoning neither clear nor convincing:—

> "Let AB, (Fig. 1.) represent the loaded roadway supported by half the arch, C being one abutment. Take any section *ab*, and make *af* equal to the horizontal strain, and *ae* equal to the weight between *a* and B or $w \times (a\text{B})$, then *e*B will be the resultant, and the line of pressures will pass through the point *e*. We must next find in what direction it passes *e*, and to do this we will consider the load $w \times (a\text{B})$ as concentrated at its centre of gravity *c*, which, if the load be uniformly distributed, bisects *a* B; then the proper direction for the strain between *c* and *e* is evidently a straight line, therefore *ce* is a tangent to the line of pressures at *e*; but because *ce* bisects *a*B, in *c*, therefore it is a tangent to a parabola, and the required curve is a parabola."



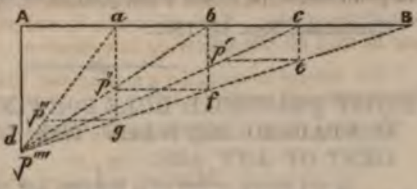
Grievous confusion characterises the passage above quoted. In the first place, the points *f* and B are confounded both in the diagram and in the reasoning, *af* being taken equal to the horizontal strain, and *ae* equal to the weight, and then *a* B being called the resultant. Secondly, it is asserted that the line of pressure will pass through the point *e*. Now as *ae* is by construction proportional to *a*B, it would follow (if that assertion were correct), that the line of pressure must be a *straight line*. Thirdly, it by no means follows that because *ce* bisects *a*B in *c* it is a tangent to a parabola in any sense that helps towards the desired demonstration. It is indeed a tangent to an arc of a parabola drawn between *e* and B, but it will be an arc of a *different* parabola for every successive position of *e*, and the point *e* will, as has been indicated, travel along a straight line in consequence of the proportion between *ae* and *a*B being constant. If the author of the investigation (after clearing up the confusion between *af* and *a*B) were to draw a line through *c*, paralllel to *fe*, to intersect *ae*, he might be in a better way to arrive at a parabola for the line of pressure.

But this is assuming all the while that the horizontal strain is everywhere the same. We do not see, however, what right the investigator has to make this assumption, if he ignores the arch theory, or treats the rib as but the lower member of a girder of which the spandrel is an essential portion.

Almost equally obscure and futile is the following endeavour to investigate "the curve proper for sustaining a rolling load, supposing the arch itself to be devoid of weight." We areh constrained to correct some errors in the original to render it intelligible.

> "Let A B, (Fig. 2.) be half the length of roadway, and let a load W roll from B to A. When the load is at *c* let *ce* equal that portion borne

by the abutment at *d*, then to find what is borne by the same pier as the load passes each of the points *b*, *a*, &c., make A*d* = W, and join *d*B, draw *ag*, *bf*, perpendicular to AB and parallel to A*d* and *ce*, to meet *d*B in *g*, *f*, then *bf*, *ag*, are the required quantities. At each of these points the direction of the strain will be *cd*, *bd*, *ad*, resolving the strain in these directions, the strains become cp', bp'', ap''', &c., and p', p'', p''' are points in the curve. From the construction in the curve it is at once evident that it is elliptical."



Even were all this correct, we should be at a loss to explain, why the curve found in the manner exemplified should be proper so sustain a rolling load. The lines *cd*, &c., in which the successive strains are conceived to be transmitted towards the abutment in every case just cut the curve, and then shoot altogether below it. If this is what is wanted, any curve will do. But the author starts with a false division of his rolling load, according to which, when the load was at the crown B, no portion whatever would be transmitted to the abutment: in fact, the distribution is as if B were the opposite abutment instead of the crown. And the curve giving by the construction shown in the diagram is not an ellipse at all, but a parabola with a horizontal axis, having its apex at *d*.

An attempt to show how to lay out the curve for an arch for a distributed and rolling load together reproduces with some variations the errors noticed in the previous processes. Here the rolling load is treated as transmitted exclusively to the nearer abutment. Just before it was considered as divided between the two abutments. No reason is adduced for these conflicting suppositions.

After a page or two on suspension bridges, the theoretical part of the work concludes with a chapter on the strength of materials, giving tabulated results from the experiments of Messrs. Eaton Hodgkinson, Stephenson, Napier, and others.

We should however give an unfair impression of the theoretical section of Mr. Humber's book, if we confined our comment to those portions which have called for stricture. These are but blots here and there in what must as a whole be regarded as a valuable compilation of some sixty or seventy pages (a third of the entire volume); recording generally in an intelligible manner the commonly received results of scientific research. With regard to the fallacies to which we have taken exception, and which stand in very unfavourable contrast with the sound reasoning to be found in the rest of the section, we can only hope that Mr. Humber may have a future opportunity of correcting them. We cannot now give consideration to the second and third sections of the text, but propose doing so in a further notice. They appear to contain much that is instructive and interesting.

◆

NEW THEORY OF THE FIGURE OF THE EARTH.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—It would have been unreasonable to have expected that those whose minds have been accustomed to run in the rut formed by established authorities would readily accept my views of the action of centrifugal force on the earth, and I prepared the way for objections by publishing the adverse opinions of one of the most eminent mathematicians of the present day. It is satisfactory to me to find that two other objectors have expressed their reasons for not agreeing with me, as it affords an opportunity for explaining more fully some points of my position, which it seems from their letters that I failed to make so clear as I should have done.

Your correspondent "R." asserts that water on the surface of a solid sphere would flow not *towards*, but *from* the place of strongest gravitation, "exactly as it would do if its density were increased at that place, gravitation remaining uniform; or if a pressure were brought to bear on it at the same place." In the foregoing passage the attraction of the fluid to the earth is regarded as if it were independent of, instead of being caused solely by, the attraction of gravitation in the mass of the globe. This is the error into which all who have objected to my theory have fallen. They confine their views to the effects of attraction and of centrifugal force on a single particle, instead of considering their effects on the mass of matter in the earth, though it is the latter which entirely governs the direction and tendency to motion of bodies on the surface. Your correspondent considers that the attraction of gravitation operates in the same manner as pressure, but the nature and action of the two forces are very different. In one case a body is itself drawn to the earth by the attraction of gravitation, whereas in the other case it is pressed down by a force distinct from its own gravity. There is the same distinction between the two forces as there exists between the attraction of a piece of iron by the inherent attraction of a magnet, and the pressure of a piece of lead on the surface of the same magnet by a spring. In the case of the magnet, the point of greatest *attraction* would be the point *towards which* the iron would be drawn; but movable particles would be propelled from the point of greatest *pressure*.

The fallacy of your correspondent's assertion that water would not flow *towards*, but *from* the place of strongest gravitation on the surface, will be further apparent on considering the effect of gravitation on the surface of a solid spheroid at rest. I feel assured he will not deny, what has been demonstrated by the most eminent mathematicians, that the attraction of gravitation on the surface of a solid spheroid of homogeneous matter, at rest, is strongest at the shortest diameter. Neither will he deny, I presume, that water poured on such a spheroid would flow towards the points of strongest attraction. Sir John Herschel, when explaining the condition of attraction on the surface of a solid spheroid at rest observes, that water would not remain at other parts of the surface than the poles (the shortest diameter) "any more than if it were thrown on the side of a hill." It being admitted, therefore, that on a spheroid at rest particles on the surface would be attracted towards the shortest diameter, it is evident that it is not only possible that the point *at which* the attraction is strongest may be the point *towards which* particles on the surface are attracted, but that it could not be otherwise. It may indeed be said, that the rotation of the spheroid would produce a difference, but the proposition of your correspondent is an absolute one, and could not be altered by change of circumstances.

The same illustration disposes also of the similar objection raised by your other correspondent, Mr. Conder, who affirms that "the stronger local attraction *at* the pole has no tendency to cause motion along the surface of the sphere *towards* the pole. There is no impulsion of matter from the equator; the impulsion is all the other way." Had he considered the cause of the stronger attraction at the poles he would not have made such assertions. It is not a "local attraction," as Mr. Conder regards it, but it is the result of the attractions of the particles of matter in all parts of the mass of the globe. If, therefore, from any cause, the matter near the poles becomes more attractive than the matter in other parts of the globe, it is contrary to reason to assume that the increased attractive power would produce repulsion. Your correspondent "R." has apparently been misled by considering what would be the effect of increased attraction at the poles on a *fluid* sphere, in which case his reasoning would correctly apply, as I explained in my paper; but it is fallacious as applied to a *solid* sphere.

Mr. Conder is more diffuse in his objections than your correspondent "R.," but they seem to be principally directed against the "idea" that the component matter of the earth is rendered lighter at the equator by the agency of centrifugal force. He says "The whole argument is based upon equivocal middle terms. To such a fallacy the only answer is, to give a correct definition of the real meaning of the terms employed." Unfortunately, however, he omits to give that answer; and though he attaches so much importance to the correct application of terms, he is far from precise in his own use of them. He speaks of "weight," "sensible weight," "inherent weight," "downward pressure," "vertical pressure," "gravitation towards the earth's centre," "passive gravitation," and "downward pressure resulting from gravitation;" and as regards those terms I plead guilty to the charge of "evincing unconsciousness of the distinctions." It appears to me, indeed, that by this multiplicity of expressions for the same thing he misleads himself, and may possibly mislead others. Since Mr. Conder has failed to give the definition of terms which he considers so all important, I will, in order to avoid mistakes, explain the sense in which I understand the terms "weight," "gravity," and "specific gravity," on which he lays the most stress. I understand *weight* to be a relative term, expressing the actual force with which a body on or near the surface of the earth is drawn towards it by the attraction of gravitation. The amount of the force may vary with the temperature, with the density of the surrounding medium, and with the position in which the body is placed. To speak of the "inherent weight" of matter, therefore, seems to be as absurd as to speak of its inherent velocity. *Gravity* is the inherent attractive power which a body possesses, independent of place or circumstances; and this it is what I suppose to be intended by "inherent weight." *Specific gravity* I understand to be the weight of a given bulk of one body compared with the weight of an equal bulk of another, or the comparative weights of equal bulks of the same kind of matter under different circumstances. Thus, a cubic inch of lead is 11·35 times heavier than a cubic inch of water when they are weighed together, and that number indicates the specific gravity of lead compared with water; but if the lead were by any change of circumstances to weigh more or less, while the water with which it was compared remained of the same density, the specific gravity of the metal would be changed. Thus, for example, if a pound of lead weighed by a spring balance at the equator weighs 11·35 times more than its bulk of water, and when weighed again with that balance nearer the pole, the same mass of lead weighs more than a pound, the specific gravity of the lead would be increased, *compared with the water at the equator*, as well as its actual weight. In this sense Sir John Herschel observes, that at the equator "the sea is lightened" by centrifugal force, and that at the poles "the water may be considered as specifically heavier."

I do not affirm that the rotation of the globe diminishes the inherent gravity of the particles of matter, but what I contend is, that by the rotation of the globe a mechanical force is introduced which tends to separate them, and to counteract the attraction of the particles to each other. I fear to extend this reply to too great a length, otherwise it might be shown that the direction of the counteracting centrifugal force is not confined to the plane of the equator, but extends radially from each particle throughout the mass of matter in the globe; and that, by thus counteracting the attraction of the particles to one another, it in fact renders the matter near the equator *specifically lighter*, though the gravitation of the particles to the sun and to other heavenly bodies remains unchanged. The illustration of the spinning top, which Mr. Conder adduces, supports my argument instead of contradicting it. The top, it is true, does not weigh less when spinning than when at rest, because the gravity of the particles continues unaltered by rotation; but the attraction of the particles among themselves is weakened by centrifugal force, and, if the rapidity of rotation were much increased, it would be altogether counteracted, and they would be torn asunder. This weakening of the force of attraction between the particles of matter by the action of centrifugal force takes place in the mass of the earth, and the attraction of gravitation on the whole surface of the globe is thereby diminished. Mr. Conder, indeed, asserts that "at the pole the vertical pressure of gravity suffers no abatement;" and he says further, "the centrifugal force is not appreciable at the pole," but these assertions must have been made without sufficient consideration, for it could readily be proved that the earth's rotation about its axis must diminish the attraction of gravitation on *all* parts of its surface.

Before I conclude I will adduce an additional illustration in support of my views of the action of centrifugal force, derived from the further consideration of the effect of gravitation on a solid spheroid brought from a state of rest into rotation about its shortest diameter. It being admitted that a particle free to move would be drawn to one of the poles of such a spheroid when at rest, it is evident that it would remain there until the spheroid had attained a velocity of rotation sufficient to overcome the polar attraction. Let it be assumed that that effect would be produced by a rate of rotation of once in twenty-three hours, and that at slower speeds the attraction towards the pole would continue to be greater than to any other part of the surface. It follows, therefore, that when rotating with the same velocity as the globe, viz., once in twenty-four hours, the parts of greatest attraction would be the poles, and that all particles on the surface would be attracted towards them, and not towards the equator. That is the position I have endeavoured to establish with respect to the earth, which may be considered to be in exactly similar circumstances to those of the assumed spheroid.

Having, as I hope satisfactorily, answered the objections of your correspondents, I purpose in your next publication to explain the probable causes of the disturbance of the equilibrium which the earth must have attained when in a fluid state, and to point out some of the consequences of my theory.

Hampstead, Sept. 13, 1861. F. C. Bakewell.

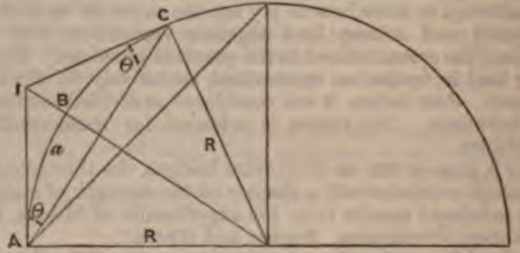
SHORT PRACTICAL RULE FOR FINDING THE ANGLE CONTAINED BETWEEN THE CHORD AND TANGENT OF ANY ARC.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

In the accompanying diagram let the arc ABC be portion of a railway curve which it is required to lay off by Mr. Rankine's method; that is, by means of the angle contained between its chord and tangent. Let AI = the tangent we use in this case, and AC = chord of arc; a = length of arc ABC, R = radius of curve, and θ = angle required. We have the following proportion, $\theta^\circ : 45^\circ :: \pi : \frac{\pi R}{2}$. π = ratio of circle to diameter = 3·1416, from which we obtain

$$\theta = \frac{90a}{\pi R} = \frac{a}{R} \times 28{\cdot}648 \quad \ldots \quad \ldots \quad (1)$$

This equation gives the value of θ in degrees and decimals for any length of arc, thus being of service in the finding of the angle for what is known to those who have used this method in the field as the "odd distances."



Supposing θ to be known (as it always is for the whole curve), by transposing the equation we find the following value for the length of the arc:—

$$a = \frac{\theta \times R}{28{\cdot}648} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

bearing in mind, that in both these equations a and R must be in the same terms.

By means of these two equations we obtain two very important data for laying out curves by this method, without requiring the use of tables of logarithms, or natural sines, &c.—very valuable, but, to say the least, very troublesome aids to calculation in the field. If in formula (1) we put $a = 1$ chain, and multiply the right-hand side of the equation by 60, we obtain for θ the following value in minutes and decimals:—

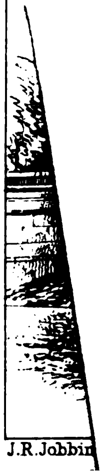
$$\theta = \frac{1719}{R}$$

which is the formula given at page 275 in the last number of the *C. E. & A. Journal.*

Dublin, Sept. 13, 1861. Thomas Cargill, C.E.

◆

Ely Cathedral.—The reconstruction of the lantern of this cathedral, as a memorial of the late Dean Peacock, is about to be commenced in a few days, from designs prepared by Mr. Gilbert Scott. The intention of the friends of the late Dean to enter on this work was announced some months since, but, as the estimated expenditure was from £5000 to £6000, some difficulty has been experienced in providing the requisite funds. Sufficient promises of support having now been obtained to justify the commencement of operations, they will be prosecuted [with energy. The new lantern, like the existing one, will be of oak cased with lead, but windows will be introduced harmonising better with the rest of the building. Mr. L'Estrange, of Hunstanton, an amateur artist of considerable taste and skill, is proceeding with the painting of the ceiling of the nave, a series of gigantic medallions representing the Creation, and other series from early Scripture history, being in course of execution.



J.R.Jobbin

ASHWICKE HALL, GLOUCESTERSHIRE.

(*With Engravings.*)

The handsome structure which is illustrated by the accompanying perspective view and plans, has been recently completed at Ashwicke, Gloucestershire, for Mr. John Orred. It is wholly built of stone, the quoins, dressings, carvings, &c., of box stone, and the walling and plain surfaces of an oolitic stone, which was quarried on the estate. In adopting the castellated style of architecture the object of the architect was to take advantage of some of the broad and massive features of that style, without attempting to make a gentleman's country residence look like or in any way resemble a castle of the middle ages, which in the nineteenth century would be an absurd anomaly. The result has been highly successful, and from many parts of the park the effect of the hall—especially from some of the lower portions—is noble and imposing. It forms a conspicuous and pleasing object from the old Roman road or Foss-way, running from Bath to Cirencester.

The whole of the details of the work have been carried out with the greatest care, and display a very considerable amount of taste. The carving especially is very beautiful, and has been, with few exceptions, drawn and designed by the architect himself. It is chiefly arranged upon natural foliage, such as the oak, hawthorn, hop, vine, lily, maple, fuschia, primrose, chrysanthemum, and is interspersed with animals, birds, monograms, heraldry, &c., furnishing matters of great interest as works of art, and yet in perfect keeping with the architecture.

The top of the tower is occupied by an iron tank, containing about 9000 gallons of water, supplying the various parts of the house and offices. The tank is filled by hydraulic rams from springs which rise in the park, and the house is surrounded by hydrants in case of fire, but which are ordinarily used for watering flowers or turf on the terraces and gardens. The entrance porch is surmounted by a hare, the crest of the proprietor, and over the arch of the entrance doorway is sculptured the quaint inscription—"Welcome the coming, speed the parting guest." The entrance hall has an oak carved and panelled ceiling, with oak herring-bone flooring, and parquetry borders. The chimney-piece is of Caen stone, elaborately carved, and of bold proportions, with fire-dog grate. On the frieze is sculptured the motto—"Fear God, and honour the queen." The principal staircase is of carved oak, with massive newels and twisted balusters. The doors and fittings of all the best rooms are of carved oak, with monograms and other devices; and the dining room has also an elaborately carved oak ceiling, and an elegant oak sideboard standing in a canopied recess. The chimney-piece is of Caen stone, tastefully enriched with a variety of birds and foliage, and bearing the inscription — "Except the Lord build the house, they labour in vain that build it." The cost, including conservatory, stables, lodges, &c., was about £20,000.

References to Plans.

GROUND PLAN.

A. Porch.
B. Entrance hall.
C. Principal staircase.
D. Morning room.
E. Library.
F. Dining room.
G. Drawing room.
H. H. Passage.
I. Mr. Orred's room.
J. Billiard room.
K. Side entrance.
L. Gentlemen's water-closet.
M. Hat and cloak room.
N. Back staircase.
O. Glass passage.
P. Conservatory.

a. Housekeeper's room.
a′. Closets.
b. Kitchen.
b′. Kitchen entrance.
c. Servants' hall.
d. Butler's pantry. *d′.* Plate closet.
e. Scullery.
f. Store closet.
g. Wicket.
h. Stairs to hot water apparatus.
i. Larder. *j.* Pantry.
k. Coals.
l. Knives and shoes.
m. Wood.
n. Trapway.
o. Kitchen court.

CHAMBER PLAN.

A. Corridor.
B. Turret staircase.
C. Principal staircase.
D. Bed room.
E. E. Dressing rooms.
F. Boudoir.
G. G. G. G. Bed rooms.
G′. G′. Bed rooms or Dressing rooms.
H. Closet.

a. Governess' room.
b. School room.
c. Nurse's room.
d. Day nursery. *e.* Night nursery.
f. Women's work room.
g. Bed room.
h. Nursemaid's closet.
i. Linen closet.
l. Back staircase.
m. m. Water closets.

The architect was Mr. J. K. Colling, of London; the builder, Mr. George Myers, of Lambeth; and the water work was executed by Messrs. Easton, Amos, and Sons, engineers, of the Grove, Southwark; the gardens and grounds, which have been most tastefully and charmingly laid out, have been arranged by Mr. Edward Milner, landscape gardener, of Sydenham.

◆

THE RE-OPENING OF LICHFIELD CATHEDRAL.

Since our last article, in February 1860, on the works of restoration and improvement then in progress at Lichfield Cathedral, the greater part of what was therein adverted to has been successfully acomplished; so that the intention, long purposed, of re-opening the choir on the 22nd ult., was actually realised, and celebrated under the most auspicious circumstances.

The chronological history of the cathedral, and its successive portions, Norman, Early English, &c., were pretty fully detailed in the article just alluded to, but it is worth while to recur to the subject, if only to note a singular coincidence or parallelism which has been detected between these several structures and corresponding ones in the Cathedral of York, as laid down by Professor Willis. From the statements of that learned authority it appears that the gradual progress of Lichfield Cathedral from the original Norman church to its present structure, as thus developed, proceeded in a curiously simultaneous manner with that of York. For instance, York had a cathedral in the Norman era (built about 1080), and so had Lichfield. Between 1154—1181, Archbishop Roger substituted for the original chancel at York a long, square-ended choir, with the aisle carried round behind the end. At Lichfield, during the same period, the large chapel was built at the end of the Norman apse; and about the beginning of the 13th century the whole Norman eastern termination was, as at York, replaced by a long square-ended choir with the low aisles behind. Next, at York the Norman transepts were rebuilt in Early English, between 1230 and 1260. The same occurred at Lichfield, beginning, as at York, with the south transept, followed by the north. The Early English work of this cathedral is shown, by the licences to dig stone, to have been in progress in 1235 and 1238. York nave, and also Lichfield, were next rebuilt in Early Decorated; and lastly, at Lichfield the elongation of the eastern part was begun at the extreme east, beyond the existing choir, by the lady-chapel, in Late Decorated (1296—1321), and followed by taking down the choir, and continuing the same work on its site westward; while the works at York followed in the same order, but forty or fifty years later. Moreover, the plans of the two cathedrals rival each other in the simplicity of their proportions.

It is perhaps needless to observe, that in the hands of so conservative a church restorer as Mr. Scott, the utmost vigilance has been exercised in preserving as far as possible all old fragments, more especially such as are of historical value: we allude more especially to the curious evidence afforded by the examination of the pillars and arches on each side of the choir, as illustrative of the abrupt transition of style in which our forefathers did not disdain frequently to indulge; and great praise must be accorded to those acting under the direction of the architect, and especially to the general superintendent of the works, Mr. Clark, for so skilfully aiding in carrying out his instructions.

To the present Dean and Chaper all honour must be accorded for their energetic and untiring labours in the prosecution of a scheme of such magnitude as the complete and systematic restoration of the beauteous fabric under their charge; nor must it be forgotten to acknowledge the munificent donations, and gifts of various kinds, which have poured in from different quarters, and which have contributed so much towards the gratifying result.

It will be seen with satisfaction (as remarked in the statement just issued by the Dean and Chapter) that the liberality of the diocese has enabled the greater part of the dilapidated or wantonly destroyed stonework to be restored,—the whitewash of long standing to be removed,—the bishop's throne and stall work to be completed,—the pavement of the choir to be ordered, though it will not be entirely laid,—and a light open screen to be substituted for the former separation of the church into two parts,—besides the introduction of many costly requisites, the organ, the font, the lettern with bible, the litany desk, lighting standards and candlesticks, books of service, embroidered altar cloth, poor's-box &c., many of which have been the gift of individual benefactors. Much yet remains to be done, and all will be proceeded with as rapidly as circumstances may permit: and among such unfinished works may be enumerated, the reredos with the sedilia; the fitting up of the lady-chapel for an early service, in conformity with the provisions of the ancient cathedral statutes; metal screens under the choir arches east of the stalls, and a low ornamented grille (or metal screen), similar in character, to be continued along the other arches, at the back of the stalls themselves; pulpit, and due supply of seats; the restoration of the windows in the south transept aisle; the re-flooring of a large part of the area; the repair of the arcading in the nave; the improvement of the debased west window; the restoration of the chapter house, and library; the provision of vestries; and by degrees, perhaps, the introduction of additional stained glass windows.

Mr. Scott's restoration of the stonework is in every sense a success. All the delicacy and characteristics of the details of the various architectural styles, and especially the Decorated, which most prevails, are brought out with surprising freshness and force. The foliage of the capitals presents all the crispness of the best-preserved originals, while the mouldings of the arches and shafts of the clustered piers are models of symmetry.

As an example of the conscientious adherence to authorities which has been displayed thoroughout, it may be remarked, that on the testimony of Dr. Stukeley, in a manuscript written in 1715, and a copy of which is given in Shaw's 'Staffordshire,' (vol. i., p. 254,) six figures have been replaced in the "middle choir," three on each side, and standing on corbels attached to the continuation of the groining shafts which support the main vaulting, in a similar manner to those against the groining shafts at the end of the lady-chapel. Stukeley's quaint record is as follows:—

> "In the middle choir, upon six of the pillars, are six figures, three of a side. The first is St. Peter, and at his feet a little cross, which shows him crucified with his head downwards. The second is the Virgin Mary. The third is Mary Magdalen, figured with the leg and part of her thigh bare, as an emblem of her wantonness. On the other side is, first, St. James; second, St. Philip; and third, St. Christopher, with Christ on his back."

The new figures, which are excellent specimens of sculpture, have been produced (as was the carving generally) by Mr. W. Farmer, of London; the cost being defrayed by donations given specially for the purpose.

The whole of the wood-fittings, which have been beautifully executed by Mr. Evans, of Ellaston, near Ashbourne, are of oak; they are of the most substantial character, and for the most part elaborately moulded and carved. The choir is arranged lengthways, so as to have a succession of stalls, twenty on each side, ranged against the line of pillars, besides two others on each side, placed obliquely, and against the large tower piers; the first on the right on entering the choir being appropriated to the Dean, and the corresponding stall on the left being allotted to the Precentor. In front of the elbowed-stalls are placed the substalls, the length divided into three equal portions, which again have book desks, of corresponding length, in front, the two extreme ones being of oak, and the centre one (intended for the chorister boys) of open brass work. In consequence of the desirableness of gaining the effect of the width of the choir aisles, as seen through the choir arches, the stalls, which have carved misereres, and are in other respects in conformity with ancient examples, will have light pierced metal-work behind, in place of the usual tabernacle-work.

The fittings we have thus described occupy the three westernmost of the bays which compose the choir. Beyond these eastward, on the south side, is the bishop's throne, a most elaborate and exquisitely carved specimen of workmanship, and still further on are the flights of steps leading to the sacrarium, the altar table, and the reredos. The altar table and reredos are replaced in their ancient positions, at the second pier westward from the lady-chapel; the table is eight feet long, of oak, and consists of boldly-designed pillars supporting a massive top. Upon the design of the reredos itself, not yet fully carried out, the utmost study has been bestowed, both in regard to its purpose, its position in combination with other features, and the materials of which it should be composed. While fully expressing its object, the whole has been treated so as to produce as light and unobstructive appearance as possible. With this aim the whole has been kept low, and the portions north and south of the table consist of open arcade work, so that a perfect view of the elegant proportions of the apsidal end of the cathedral, and especially the stained glass in its windows, may be almost uninterruptedly obtained. A reference to the illustration accompanying the article in our number for February 1860, already referred to, will give a good idea of the reredos as being executed, but the design of the centre part has been somewhat altered, as well as the number of side arches, and the several levels. The greater part of its ornamental decorations will be derived from arts practised, or materials procured, in the diocese. Thus, it will be constructed mainly of alabaster, with the shafts of Derbyshire and other marbles, the inlaying and mosaics of the same, with fluor spar, encaustic tiles, &c. occasionally interspersed. In the open arcade another variety of colour will be attained by means of the scroll metal-work which fills the lower portion. A third illustration, showing the lady-chapel as seen from the north aisle of the choir, will be found in the number of this Journal for January last.

The pavement throughout is of the most sumptuous description, and composed of tiles made expressly for the purpose, used in combination with various marbles. A portion of this pavement has been liberally presented by Mr. C. M. Campbell, the nephew of the late Mr. Herbert Minton. Beyond the stalls eastward, a space, two bays in depth, and entirely free, except that part on which stands the bishop's throne, admits of a different treatment, and will, when finished, present an unique effect. This large area is mapped out into four squares, surrounded by mosaic inlaid borders, and each consisting of a central "subject," with subordinate figures in circles at the four angles. These subjects, which are formed in cement let into stone, are designed by Messrs. Clayton and Bell, from a scheme prepared by the Rev. E. R. Pitman, of Rugeley, who with no small skill has embodied in it certain leading events in the history of the Diocese and Cathedral of Lichfield, which had been placed before him.

Metal work is extensively introduced in the cathedral restorations, and the whole (with the exception of the lettern, which is by Hardman), has been entrusted to the experienced hand of Mr. Skidmore, of Coventry. The three large screens and gates which sever the choir from the tower and transepts are the first objects which meet the eye in approaching the choir and its aisles from the west. The large central screen completely occupies the space between the tower piers, and rises, at its summit, to a height of 25 feet. In some respects the prominent features of the design remind one of that at Ely, save that the latter is principally of oak. In the centre is a lofty arch, cusped, and hooded by a richly crocketed gable, surmounted by a cross. In the lower part are two handsome brass gates, designed after an ancient example. The sides of the screen consist each of an arcade, springing from twisted shafts, with elegant capitals in hammered metal, and in the design of which conventional and natural forms are alternated. Above these arches the space up to the cornice is filled by large cusped circles, to the bases of which are fixed corbels, upon which stands a series of angels in bronze, exquisitely modelled. Between the horizontal bars of the cornice is introduced rich foliated scroll-work, and, above, there is a bold ornamental cresting continued along. The lower parts of the screen are treated panel-wise, and filled in with light quatrefoils. The screens across the north and south aisles are equally meritorious in point of design, but, of course, less in height and elaboration than the principal one.

The choristers' desks are wholly of brass, the front being filled in with bold scroll foliage; the altar rail is also of brass, consisting merely of coupled shafts at intervals, supporting the rail, but fixed at the bottom to a continuous flat metal plate, on which is chased a suitable pattern.

The position for the organ in the new arrangement was a point that occasioned much perplexity, but it was eventually determined to place it on the north side of the choir, in the bay formed by the junction of the transept with the choir aisle. This position has necessitated much contrivance in the construction of the organ itself, which is an entirely new instrument, the munificent donation of Mr. Spoode, who commissioned its erection at a cost of £1000. The maker is Mr. Holdich, of the Euston-road, London, who has exercised much ingenuity in the arrangement and adjusting of the various parts under the circumstances. It has three rows of keys, and a large independent pedal organ, the number of pipes to each respectively being 1056, 828, 312, and 311, making a total of 2507 pipes. The total number of stops is 60.

In one of the western arches, on the north side of the nave, a costly new font has recently been placed, the gift of the dean's lady, and a few friends. The design was furnished by Mr. W. Slater, of London. It is of square form, with the angles canted off, against which stand detached figures. There are four subjects carved in panels on the principal faces, representing the Passage of the Red Sea, Noah's entry into the Ark, the Baptism of our Lord, and the Resurrection. The bowl is of Caen stone, supported on a large central column of Irish marble, having four smaller ones, of Languedoc, at the angles. In other portions Derbyshire marble is introduced, with alabaster. The whole has been executed in admirable taste by Mr. J. Forsyth, of London.

The estimated cost of the different items is as follows:—bishop's throne, £400; choir stalls, sub-stalls, and fronts, £2500; choir screen, £800; aisle gates, £160; lighting, about £600; pavement (?); reredos, £1800; the entire expense will amount to nearly £12,000. Nor does this sum include the whole of what is contemplated; the chapter-house and the nave will still remain to be done: still, we may hope that the zeal and perseverance which have been so far successful, will ultimately be rewarded by the complete realisation of the noble project.

THE STATICS OF BRIDGES.

(Continued from page 226.)

The example of the constructive method of determining the Line of Pressure already given (p. 226) will have made it sufficiently clear that the similarity of form between that line and the Curve of Moments furnishes the key of the whole process. In order that the course of reasoning might be the more readily followed, it seemed necessary (in Fig. 19) to draw a Curve of Moments (*am*), as well as the Line of Pressure (*ad*).

But although necessary in order to demonstration, the Curve of Moments practically never need be drawn. The horizontal distances between the ordinates 1′ 1″, 2′ 2″, 3′ 3″, &c. of the rectified Curve of Moments on the right-hand side of the figure are all that it is essential to find, and these distances may be plotted at once by reading off the moment of each section successively to such a horizontal scale as may be considered convenient. Thus (referring to column 4 of the table given in page 225) 5·39, the moment of the section (0, 1), gives either the distance 0 1′, or a proportionate distance, which will answer the purpose of rectification equally well. 16·30, the moment of (1, 2), in the same way gives the distance 1′ 2′, or a proportionate distance. The plotting of these successive intervals may afterwards be checked by comparing the extreme distance 0 13′ with the sum of the moments, or moment of the semi-arch, 1341·24, with which, if the plotting be exact, it will be found to correspond.

By these means the ordinates are at once set up at such proportionate distances that the Curve of Moments, if drawn on equidistant ordinates and then transferred to these, would become a straight line. Knowing this, we know that the Line of Pressure also will, if displayed on these ordinates, become a straight line.

In fact, since a Curve of Moments can but be plotted to a perfectly arbitrary vertical scale, and since its ordinates give the proportion of the ordinates of the Line of Pressure, the latter may justly be regarded as no less than the Curve of Moments plotted to a definite vertical scale. It is requisite that this scale be such as to read the moment of the semi-arch (1341·24 in the instance under consideration) for the crown of the Line of Pressure; the heights being taken from the horizontal line passing through its lower extremity.

The Line of Pressure is thus at once the Curve of Moments and the Path of Resultant Pressure; the latter at least for all arches that may be considered as finding their equilibrium in simple compression, without exercise of transverse strength.

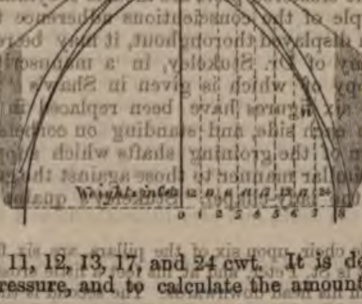
On looking at the table on page 225 already referred to, and observing the steps by which the figures for the "Moment of each Section" (in the 4th column) were obtained, it will be seen that they are merely twice the successive values of the load between the crown and the middle of each section. Thus 5·39 is equal to the weight of the section (0,1); or to twice the weight from 0 to a point midway between 0 and 1. 16·30 is equal to double the weight of (0,1) added to once the weight of (1,2): this is equivalent to twice the weight from 0 to a point midway between 1 and 2: and so on. The reason of taking *twice* these successive aggregate weights is, that by so doing the figures in the 4th column can be obtained at once by simple addition, without stopping to halve the weight of each section. The sum total, 1341·24 (in the 5th column), will require to be multiplied by half the common interval between the section lines, in order to give the actual moment of the semi-arch. But in the present instance, the half interval being 2 feet, the multiplier is unity, and leaves the figures unaltered.

To obtain the Horizontal Thrust, it is only necessary to divide the moment of the semi-arch by the rise of the Line of Pressure. In Fig. 19 the rise of the Line of Pressure is 13 feet, and the moment 1341·24, divided by the rise 13, gives 103·17 for the Horizontal Thrust.

We now proceed to give further examples of the application of our method to arches of various forms.

Fig. 21 represents a Chancel Arch of 21 ft. 4 in. span. The half arch is divided into eight sections, each section having a horizontal width of 1 ft. 4 in. The respective weights of the sections in cwts. (including the portion of wall, &c. carried by each) are 12, 11, 11, 11, 12, 13, 17, and 24 cwt. It is desired to draw the Line of Pressure, and to calculate the amount of horizontal thrust.

Fig. 21.



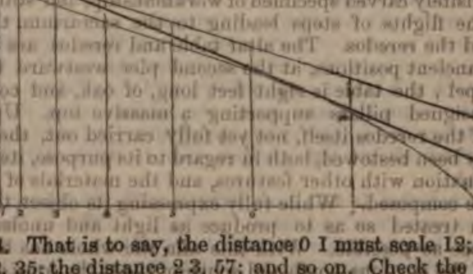
The first step is to find (by the addition of the weights) the coefficients for the moments of the sections as in the following table:—

1. Reference to Sections.	2. Weight of each Section.	3. Process of addition.	4. Coefficient for Moment; or Twice the Aggregate Weight from Crown to centre of each Section.
No.	Cwt.		Cwt.
0,1	12	12=	12
1,2	11	12+12+11=	35
2,3	11	35+11+11=	57
3,4	11	57+11+11=	79
4,5	12	79+11+12=	102
5,6	13	102+12+13=	127
6,7	17	127+13+17=	157
7,8	24	157+17+24=	198
Sum of weights	... 111	Sum of Moments	 767

To check the additions, observe that the weight (24) of the last section added to its coefficient of moment (198) is equal to twice the sum (111) of weights.

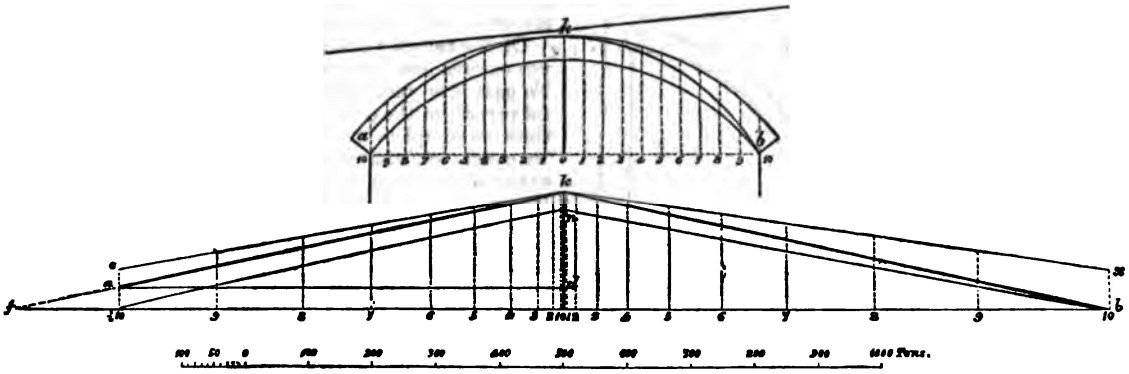
Now take any convenient horizontal scale for cwts., and set up the ordinates in Fig. 22 at distances answering to the figures in column 4. That is to say, the distance 0 1 must scale 12; the distance 1 2, 35; the distance 2 3, 57: and so on. Check the plotting by observing that the total distance 0 8 corresponds on the scale to 767, the coefficient for the Sum of Moments, or moment of semi-arch.

Fig. 22.



12·25 feet, and the moment of the right semi-arch being 854 tons, the horizontal thrust is $\frac{854}{12 \cdot 25}$, or 70 tons. This thrust is generated by the right semi-arch, which has two points of rupture; the left half of the arch, which has no inner point of rupture, standing by the thrust impressed on it through the action of the right, or more heavily loaded, half of the arch.

FIG. 24.



Horizontal Scale of Moments for distances of Ordinates.

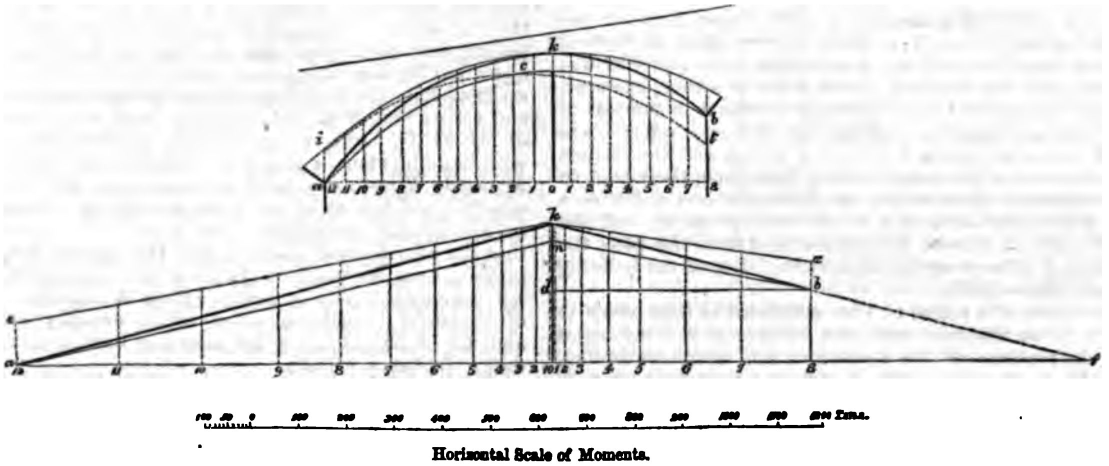
For a given load, rise, and span, that arch will be the strongest of which the points of rupture are at crown and springing; because it will allow the greatest rise to its Line of Pressure, and consequently stand with the least thrust. Examined by this rule, the arch in Fig. 24 is not the strongest that could be devised for the unequal loading, for, although there is a point of rupture at springing on the right side, there is no lower point of rupture at all on the left side. So that the thrust is greater than is needed for the support of the left, although but just sufficient to support the right semi-arch.

It is therefore advisable, when there is a great and permanent excess of loading on the one side of an arch (as will happen under a steeply inclined roadway), to give the arch a "cant" or tilt, by raising the level of springing on the one side, and lowering it on the other, so as to get a point of rupture at intrados on each side.

Fig. 25 illustrates this. A road, at an inclination of 1 in 8, has to be carried across a span of 40 feet by an arch, of which the radius of intrados is 30 feet, the thickness at crown 2 feet, and at springing, 3 feet. There must nowhere be less than 1 foot of road metalling over the top of the arch. The breadth of the arch is 16 feet.

The dotted line *ict* represents the intrados of an arch fulfilling these conditions, having the points of springing *i* and *t* on one level, with a rise of 7′ 8″ to its crown at *c*. The line of extrados is omitted, to prevent confusion. This arch would stand with a thrust of 89 tons.

FIG. 25.


k
c
i
t
a
b
m
d
e
x
f
12
11
10
9
8
7
6
5
4
3
2
1
0
100 50 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 Tons.

Horizontal Scale of Moments.

The full lines represent the same arch tilted over by raising the springing on the right to *b*, and lowering that on the left to *a*. This arrangement reduces to some extent the inequality of the loading. But its chief advantage is, that it gives points of rupture at springing on both sides, so as to reduce the thrust to a minimum.

The point where the load divides will be at *k*, where the joints of the voussoirs become vertical. Calling the ordinate at this point zero, divide the arch and loading into 2 feet sections by ordinates numbered either way, up to 8 on the right hand and 12 on the left. The weights (in tons) and moments of the sections are given in the following tables.

Left Semi-arch.

1. Reference.	2. Weight of each Section.	3. Moment of each Section.
No.	Tons.	
0, 1	7	7
1, 2	6	20
2, 3	6	32
3, 4	7	45
4, 5	7	59
5, 6	8	74
6, 7	9	91
7, 8	10	110
8, 9	11	131
9, 10	13	155
10, 11	16	184
11, 12	19	219
Total ...	119	1127

Right Semi-arch.

1. Reference.	2. Weight of each Section.	3. Moment of each Section.
No.	Tons.	
0, 1	7	7
1, 2	7	21
2, 3	8	36
3, 4	9	53
4, 5	10	72
5, 6	11	93
6, 7	13	117
7, 8	15	145
Total ...	80	544

Having these moments, construct the diagram for straightening the Line of Pressure, on which extrados and intrados will be represented by the lines *ekx*, *anb*. The left and right branches of the Line of Pressure are given by the straight lines *ak* and *kb*, forming equal angles with the ordinates: (*kb*, if produced to *f*, would cut off a base line *of*, equal to *oa*.) The Line of Pressure thus determined is shown on the elevation of the arch by the dark line *akb*.

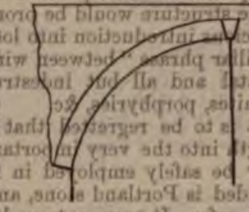
The rise of the left branch of the Line of Pressure is *ko* =

70*

14′ 0″. The corresponding moment (1127 tons), divided by this rise, gives 80½ tons for the Horizontal Thrust. The same thrust is obtained by dividing the moment (544 tons) of the other side of the arch by *kd* = 6′ 9″, which is the rise of the right branch of the Line of Pressure.

Comparing this thrust (80½ tons), with that previously given (89 tons), we find that, in this case, nearly ten per cent. of the thrust is saved by tilting the arch.[*]

FIG. 26.



When one abutment carries the *whole* of the load, the bridge assumes the form of a semi-arch, the crown bearing against the other abutment, which supplies a merely horizontal reaction. An illustration is given in Fig. 26. In such a case there are but two points of rupture. Any further inequality of level between its extremities would convert the structure into what could not be called an arch so properly as a flying buttress, and the highest voussoir would transmit an upward as well as a horizontal thrust to the wall against which it abutted.

ON THE STONE EMPLOYED IN THE HOUSES OF PARLIAMENT, AND ITS DECAY.

In another part of the present number of this Journal will be found the report of the committee which has been sitting with a view to investigate the causes and nature of the decay of the stone in the New Houses of Parliament, and the remedies or preventives proposed; and to indicate what quality of stone might with safety be employed in any future buildings of importance in the metropolis.

The main circumstances of the case are so well known, that it is hardly necessary to recapitulate them, except in the most brief manner. The New Palace at Westminster was commenced some two or three and twenty years ago; and before the masonry of the building was begun a commission was appointed (A.D. 1836) to examine and report upon all the available quarries from which building stone might be procured, and to recommend what stone was the best. This commission was composed of Sir Charles Barry, Sir Henry De la Beche, Mr. William Smith, and Mr. C. H. Smith; and after an elaborate and prolonged inquiry these gentlemen produced a detailed report, familiar to all who have to make use of stone for building purposes, on account of its comprehensive enumeration and description of the principal English quarries and their products. In this report the magnesian limestone of Bolsover Moor was recommended for adoption in the building: it however subsequently appeared that the quarry at Bolsover was not capable of furnishing stones of even moderately large dimensions, and that consequently this recommendation could not be carried out. The neighbourhood being further examined, other quarries were discovered—or at least beds of stone convenient for quarrying were discovered, which were believed to furnish a material in every respect fitted for the work; and the use of stone from these quarries (those at Anston) having been sanctioned by the commission, that material was employed through the building. At or about this time, however, there appear to have been the following variations in the part of the neighbourhood selected. First the Bolsover quarry was abandoned before any stone had been quarried, and the Stone's End quarries were selected and worked for a time; these were in turn exchanged for those at Mansfield Woodhouse; and after a time the last-named stone was in its turn given up, and the getting of stone at Anston commenced; and from this place the stone continued to be procured till the completion of the building (Evidence, § 1900—1917).

After the lapse of a period of time estimated at from seven to eight years by the witnesses examined, symptoms of decay began to appear in portions of the stone, and this decay continuing, many expedients were proposed and experimentally applied, with a view to finding out the best means of achieving the prevention or cure of such decay: and at last, the matter having been dragged into notice by the efforts of the proprietors of rival indurating processes, each endeavouring to procure public patronage for his nostrum; and having also really assumed an importance worthy of the most careful scientific scrutiny, the whole question was brought before the Royal Institute of British Architects by Mr. Tite, in the early part of this year, and was considered at great length by that body. This was immediately followed by the appointment of a commission composed of architects, engineers, chemists, and geologists of eminence, whose sittings extended over a period of nearly six months, and whose conclusions are embodied in the recent official report already mentioned.

Of the report we shall say less than we otherwise might had not our readers the opportunity of judging of it for themselves. To us it is an unsatisfactory document, and although, after a careful perusal of the evidence, conflicting as it is on some points, and showing complete want of data for forming a judgment on others, we cannot say that there was ground for a thoroughly decided expression of opinion, we cannot but feel that in some respects less guarded and ambiguous language would have been admissible—we had almost said was called for. A few words from a contemporary, written with reference to an important report on a branch of public service, prepared by a no less eminent commission than the one which sat on the question of the decay of stone, are so apposite, that we make no apology for quoting them here:—

"A commission formed on the eclectic principle is apt to break down. The opinions of its members are so various and conflicting that their report is generally lowered to the standard of a compromise. If unanimity is obtained, it is at the expense of completeness and sincerity: and the individual convictions of each member of the body would probably be entitled to more weight than the mosaic work to which all of them have put their names. Nay, we even think that the individual recommendations of the assistant commissioners, each one speaking in his own name, are more judicious and practical than those of the commission itself."[*]

The reports by the sub-committee of chemists will be read with interest by all scientific men, and are of great value; nor is the least part of the advantage to be gained from them the knowledge that the problem of the induration of soft or decaying stone remains yet unsolved—this at least we may rest assured of, after the very careful and impartial testing and investigation which these processes have received. Perhaps it is not altogether a subject of regret that we are not yet in possession of the secret for employing bad stone and converting it artificially into good, and that our only resource is the careful selection of stone that really is sound; and if the result of these inquiries be to draw more attention to the importance of carefully choosing the stone for buildings in the metropolis, great good will have been accomplished.

The evidence appended to this report will well repay perusal, and will lead the careful reader to form conclusions on points relating both to the real cause of the existence of decay in the stone of the Houses of Parliament, to the danger of similar misfortunes under any system of contract whatever, and to the course to be pursued in future buildings; some of which are rather implied than expressed in the report. It appears to us, that the evidence seems to prove that, though a selection of stone was made, and carefully made, and a fairly good stone was after all chosen, yet the very best stone available was not actually selected, for we learn (as has been already alluded to) that the Mansfield Woodhouse stone, having been at one time preferred, was given up, the reason assigned being that supplies sufficiently large could not be procured; and yet we find, from the singularly lucid and distinct evidence of Mr. G. G. Scott, whose intimate and accurate acquaintance with building stone is clearly evident in all his answers, that the Mansfield Woodhouse stone is better than that of the Anston quarries, and it is to be had *at the present day* in large blocks and in considerable quantities. How much it is a cause of regret that the efforts since made to put this quarry into an efficient position were not made at the time the building of the Houses was commenced, may be gathered from the fact that those blocks of Mansfield Woodhouse stone which actually were supplied, and are in the building, are stated to have uniformly escaped decay (Evidence, § 1925).

Further, it appears that no supervision was exercised on the part of the government or the architect over the working of the quarry; and it does not appear that, although the power of supervision existed on the works, there was any exercise of it; for the builder, Mr. Grissell, gives it as his evidence that certainly not more than half a dozen stones were rejected for want of hardness throughout the whole work (Evidence, § 493). That such supervision might, in the opinion of the commission, have been beneficially exercised, is proved by the strong expression of their regret that Mr. C. H. Smith was not actually employed, as had been proposed, to inspect all the stone, block by block.

---

[*] In the foregoing examples it has been assumed (as is invariably done) that the crown of the Line of Pressure, or point where the load divides, will fix itself where the joint of the voussoirs becomes vertical, since no weight is supposed to be transmitted through a vertical joint. This is keeping on the safe side. In reality, even in a dry arch, the "cone of resistance" for the surfaces in contact would be such as to allow the crown of the Line of Pressure to shift considerably towards the overloaded side.

[*] *Edinburgh Review*, July 1861, p. 6.

Probably the commission really did not care or wish to elicit more decisively the fact that the stone, which was quarried just as it came (with the exception of certain inferior beds), and was sent up to London just as it was quarried, really was unequal in texture, and ought to have been most carefully scrutinised by a disinterested and thoroughly skilled judge. We cannot otherwise account for the absence from the evidence of certain matters which it would have been otherwise easy to prove. The only overlookers who were examined, who state that they were *masons by trade*, were persons who had been engaged on the building on the part of the contractors. There is nothing to show that either Mr. Quarm, or any of the four or five clerks of works under him, was practically acquainted with stone; and, if report speaks true, it would be difficult to prove that that qualification was possessed by any one of them. On the other hand, while on the part of those employed by the contractors there is evidence to prove the generally satisfactory character of the material, there is enough (especially taking into account certain transactions with reference to the stone for Lincoln's Inn) to prove that the foremen were duly alive to what they supposed their masters' interests, and would not have needlessly invited minute criticism upon individual pieces of stone.

One class of evidence however, which would have helped to clear up this part of the question materially, is remarkably absent. No mason or sculptor who used a chisel upon the stone appeared before the committee, and yet none but the masons actually working a block, or persons perfectly familiar with stone and making trial drafts with a chisel, are quite aware of the degree of softness and hardness of stone. Supposing it had been proved in evidence that of two masons working at the same work on two different blocks of Anston stone, one could have easily completed in four days what the other found it hard work to get through in six, would not the commission have felt justified in deciding that the secret of the non-success of the building was the unequal quality of the stone, and the want of proper disinterested superintendence.

Such evidence as this could not have been obtained from any of the "practical" men employed, as neither the clerks of the works nor the general foreman of the builder would be quite aware of such a fact—for of course, true to the rules, or at least the customs of the trade, the mason with the soft stone would take care not to outstrip his neighbour in the amount of work done, unless working "piecework." None but masons or carvers, we repeat, could have enlightened the committee on this point, and no such witnesses were called. We have good reason to believe that had such evidence been produced the supposition we have now made would have appeared in the present report as an ascertained fact.

As to the possibility of obtaining a very satisfactory result in London from the employment of magnesian limestone when selected with care, the report of the sub-committee who examined London buildings was conclusive. They reported that the two buildings where the stone was in the most satisfactory condition were the Museum of Economic Geology, in Jermyn-street, and the Amicable Insurance Office, in Fleet-street. The stone for the museum was selected and its excellence watched by the late Sir Henry De la Beche. The committee do not however seem to have been apprised of the fact that any special care had been taken in the other case. The fact of the matter is, however, that the architect of the Amicable (the late Mr. Samuel Beazley) selected the stone himself with the greatest care, personally visiting the quarry—in fact, so much personal attention did he devote to this point, that the board of the company are understood to have voluntarily paid him a hundred guineas in addition to the commission upon the building, in acknowledgement of these services; that their value was not underrated will be apparent to anyone who inspects the building at the present day, and notices the perfect state of preservation in which its stonework remains after nearly twenty years' exposure.

The first lesson for the future now taught seems, then, to be that a most careful examination of the stone employed in buildings exposed to the London atmosphere, block by block, and by a skilful mason, is essential to success. The second seems to be, that the judicious selection of very hard varieties of stones, and their employment in certain situations in the building, would probably be a most advantageous proceeding.

From the evidence of Mr. Burnell we gather that this is a common practice in France (Evidence, § 1307), and from the tenor of the report it is clear that the opinion of the committee inclined very much to the view that the decay of such blocks of stone as are liable to decay, is accelerated or retarded according to the position they occupy in the building. The stone, wherever exposed to the soaking or dripping of water, and disadvantageously placed for being dried by the wind, is much more apt to decay than in other parts of the building; and the durability of a stone structure would be promoted no less than its beauty by the judicious introduction into localities such as are described by the familiar phrase "between wind and water," of some of the ornamental and all but indestructible materials furnished by our granites, porphyries, &c.

It is to be regretted that the committee did not go more at length into the very important practical question of what stones may be safely employed in London: the only material recommended is Portland stone, and few recommendations could have been safer. It appears to us however, that had it been within the province of the committee to advance suggestions, they might have been disposed to recommend, as one of their number actually does in his evidence, the adoption of some of the better sorts of sandstone, as likely to be attended with more uniformly successful results than have followed the employment of limestone. These stones are largely employed in the north of England and in Scotland, and are rarely to be seen decayed, even in the worst atmosphere. Perhaps the finest provincial building in Great Britain is St. George's Hall, at Liverpool, and it stands in a most exposed situation, and in an atmosphere almost if not quite as injurious as that of London. This buildings is in a wonderful state of preservation, and is almost as conspicuous for the beauty and uniformity of its material. It is built of the Stancliff or Darley Dale stone—the stone adopted for the new Assize Courts at Manchester. This stone is no doubt the finest stone of its class, perhaps the finest building stone in England, but its durability is closely approached by the produce of other quarries; and after the results of the employment of magnesian limestone under circumstances which, after all is said, were more favourable than can ordinarily be commanded, we cannot but think that the beauty and good preservation of such sandstone buildings as the one to which we have alluded entitles the material of which they are constructed to claim a high position among the stones must likely to be successful in resisting the unfavourable atmospheric conditions of the British metropolis.

FIGURE OF THE EARTH.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—With reference to Mr. Bakewell's remarks in your Journal for October, on my statement that water would tend to flow from the point of strongest gravitation on the surface of a sphere, I have to explain (what perhaps I did not make sufficiently clear at first), that I meant that statement to apply to the case in which the sphere is a figure of equilibrium; that is, a figure to the surface of which the direction of gravity is everywhere perpendicular. If such a sphere be covered with a shell or sheet of water, and if gravity, still continuing everywhere perpendicular to the surface of the sphere, becomes more intense at a certain point than it is elsewhere, the portion of the mass of water which is above and nearly above that point will tend to descend, which it can only do by spreading out laterally, and forcing aside the adjacent particles, and so causing currents to run from the point where gravity is most intense.

The waters of the ocean flow towards the points where the earth's attraction on them is partially counteracted by that of the moon, and from the points where the earth's and the moon's attraction co-operate.

I have further to state, that having considered Mr. Bakewell's letter in your October number, I must admit that, as he supposes, I did not fully understand his letter in your August number, and that his views now appear to me to be less open to objection than they did before. In fact, if I now rightly understand them, I can only see two points in them which appear to me to be erroneous. One is that (unless I again mistake Mr. Bakewell's meaning) he seems to consider that particles movable, but not revolving, on the surface of an oblate spheroid tend to move towards the nearest pole, *because it is the point where attraction is strongest*. The pole is the point where attraction is strongest, and the particles do tend to move towards it; but not for that reason, but because the direction of attraction at every point between the equator and the pole is oblique to the surface in a direction towards the pole; in short, because towards the pole is *down hill.* The other point in which I think Mr. Bakewell is mistaken is, that he conceives he has detected an error in the existing theory of the figure of the earth; whereas it is only a defect in the ordinary mode of stating that theory.

It is unquestionably true, that supposing a loose particle to exist on the surface of an oblate spheroidal planet, and to have *no motion of revolution* about the axis of that planet, the particle would tend to approach the nearest pole of the planet, because of the above-mentioned obliquity of the attraction to the planet's surface. There is a certain velocity of revolution which *the loose particle* must have, in order that its centrifugal force may exactly counteract the obliquity of the planet's attraction; and should the velocity of revolution of *the loose particle* fall short of that amount it will still tend to approach the pole. On the other hand, a loose particle with a *greater* velocity of revolution than is necessary to counteract the obliquity of the planet's attraction, tends to move towards the equator.

One of the chief mathematical problems of the existing theory of the figure of the earth is, to find the relation between the ellipticity or flattening of a spheroidal planet, and the velocity of revolution which is just sufficient to counteract the tangential component, acting towards the nearest pole, of the planet's attraction on a loose particle, so that the *effective* part of that attraction shall be everywhere perpendicular to the surface of the spheroid, and the loose particle shall not tend to shift its position.

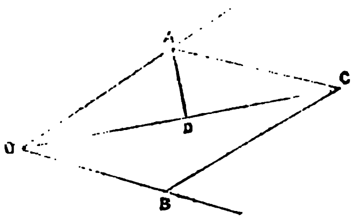
The defect in the ordinary mode of explaining this problem is, that the centrifugal force which counteracts the tangential component of the attraction on a particle is frequently mentioned as a direct effect of *the rotation of the body of the planet;* whereas it is a direct effect of *the revolution of the loose particle;* and unless that particle is carried round along with the planet's surface, its centrifugal force will be null or insufficient, and it will tend to move towards the nearest pole, as Mr. Bakewell states.

R.

SKEW-BEVEL GEARING.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—It is desirable that the attention of designers and constructors of mechanism should be called to a paper on skew-bevel gearing (*engrénage hyperboloïdique*) in the *Bulletin de la Société pour l'Encouragement de l'Industrie Nationale*, for March 1861, in which the author, M. Bélanger, points out and rectifies an error into which other writers on mechanism have fallen. It is well known that, in order to connect by means of toothed wheels two axes which are neither parallel nor intersecting, the pitch-surfaces of the two wheels should be portions of hyperboloids, described about each of the two axes by the revolution of an oblique straight line, called the "generating line," at the end of an arm, the sum of the arms being equal to the perpendicular distance between the axes. To find the direction of the generating line, let OA, OB, represent the projections of the axes on a plane perpendicular to their common perpendicular; take OA and OB proportional to the required angular velocities of the two wheels; complete the parallelogram OACB, and its diagonal OC will be the projection of the generating line. The common but erroneous mode of finding the lengths of the arms is to divide the common perpendicular into two segments inversely proportional to the angular velocities. This however is correct only when the axes are parallel, and the wheels become common spur wheels.



The correct method demonstrated by M. Bélanger is as follows:—Let fall a perpendicular, such as AD, on the diagonal from one of the angles A or B, and divide the common perpendicular into two segments proportional to the segments into which D divides the diagonal, the shorter segment being next the axis about which the angular velocity is to be the greater: these will be the required arms.—I am, &c.

W. J. Macquorn Rankine.

Glasgow, 21st October, 1861.

THE PATENT LAWS.

During the recent meeting of the British Association for the Advancement of Science the patent laws were several times brought under consideration: first on the address of the president, next on the presentation of the report of the committee on those laws, they were discussed on the reading of a paper on the patent laws by Prof. Rogers, and the president again alluded to the subject in his concluding address. Nearly all the speakers, with the exception of Sir William Armstrong and Prof. Rogers, were agreed on the general principle that inventors ought to be secured in the possession of their inventions, though the present means of doing so were considered very objectionable, and ought to be amended. Sir William Armstrong and Prof. Rogers, on the contrary, contended that patent monopolies retard the progress of invention, and are injurious to the public, and that inventors would be sufficiently rewarded by having priority in the market, by secrecy, or in certain cases, where the inventions are of great public utility, they should be rewarded by the government. It was, indeed, contended that inventions do not come within that definition of property which it is the duty of government to protect. Patentees appeared to be regarded by those gentlemen as if they were a class who preyed on the community, without doing any good, and that inventors should be outlawed.

There is surely no property to which a man can have a stronger claim than to the product of his own brain, especially when he has spent much time and money in bringing it to perfection. But it is objected that the same idea often occurs to several persons independently, the one having as much claim to be the inventor as the others, and that it is a great hardship for a man who has equal merit to be excluded from all advantage because he may happen to apply for a patent a few months or a few days later. There is no doubt a seeming hardship in such a case, but it is not greater than we are accustomed to witness daily, without complaining, in the disposition of landed property, where several brothers, each having an equal natural claim, are set aside because one of them has been born a year perhaps, and sometimes only a few minutes, before the others. If it be considered to the advantage of society that such a hardship should exist, and that, without any merit whatever, priority of birth should give a right to monopolise land, there cannot fairly be an outcry raised against the right to monopolise an invention acquired by priority of merit.

The strongest objection that has been urged against the monopoly of an invention is, that it not only prevents the free use of it by others, but it obstructs further improvements. That objection however does not apply to the principle of granting protection to inventors, but to the manner and conditions of the grant, and it involves the question of an amendment of the patent laws, on the necessity of which all are agreed.

The amended law of 1854 was so vast an improvement on the old system, that inventors were not inclined to scrutinise very closely the boon that had been conferred on them. Now, however, that they have had some years' experience of its advantages, they have become acquainted also with its defects, and are anxious to have them remedied. The chief defect of the existing law is a remnant of the old system, according to which patents are not granted as rewards of merit, but are sold to the first comer. There are now certain useful forms prescribed for the purpose of defining the object of the invention for which letters patent are applied, and for preventing differing inventions from being included in the same patent; but when those forms are complied with, letters patent are still granted, without any regard to the utility or novelty of the invention. So little attention is paid to the novelty of the inventors' claim, that if ten applications for letters patent, for substantially the same invention, were made within a month, no difficulty would be raised on that account, and the patentees would be left to make good their respective claims in a court of law. The conflicting claims arising from this indiscriminate sale of letters patent occasioned much annoyance and litigation under the old system, and deprived the protection obtained of much of its value; and the great increase of applications for patents—in consequence of the reduction of the price—has multiplied the conflicting claims nearly tenfold. At the time when fees to the government officers amounted to about £100 for each patent, the average annual number obtained was 400; but now that the fees have been reduced to £25, the average number of patents granted exceeds 3000 in each year. It is evident that a large proportion of these fancied inventions must be entirely worthless. Sir Wm. Armstrong expressed the opinion that not one in twenty was of any value, and we believe, had he said one in a hundred he would have been nearer the truth. This enormous increase in the number of applications for letters patent has had the further bad effect of diminishing the check which private interest formerly imposed on the grant of patents for old and similar inventions. It was the custom for those who were interested in an invention to enter a *caveat* at the Patent Office against the granting of any patent for a similiar object; and the parties received notice when any such application was made, and entered an opposition. The applicant then explained his invention to the attorney or soliciter general, who afterwards heard the objectors, and if the inventions were alike the patent was refused. In the present throng of applications, however, it is scarcely worth the sacrifice of time and money necessary to oppose the grant of a patent, and thus the restraining check is weakened, and the flood of claimants for protection overpowers opposition.

When the bill for the amendment of the patent law was introduced into parliament, it contained several clauses making provision for a preliminary examination of inventions before competent judges, for the purpose of determining their novelty and claims to be protected; but in the progress of the bill through parliament those valuable clauses were omitted, and the act contains no restrictive provisions of the kind. The necessity for such a tribunal becomes more and more evident as the increasing number of protected inventions multiplies conflicting claims to the same invention. It is, indeed, to the interest of inventors more than of the public that every claim should be carefully examined before it is converted into a monopoly—if that can be so called which is assailed by competitors on every side. If the merits of each alleged invention were investigated by a competent examiner, the grant of letters patent to such inventions as were deemed worthy of the privilege, would be an honour, and a patented article would have increased value in the market; but by the present system of selling patents to all comers, they have entirely lost their value in public estimation. The careful examination of a specification by competent authority before the grant of a patent would be *primâ facie* evidence of its novelty, and should protect the patentee against the infringement of his monopoly, unless strong evidence were adduced against it. But at present a patent affords no protection; it merely recognises an invention to be property, the possession of which anyone may contest.

The report of the committee on the patent laws, read in the Mechanical Section of the British Association, was founded upon and embodied the following resolutions, agreed on by the patent committee in London:—

"1. That all applications for grants of letters patent should be subjected to a preliminary investigation before a special tribunal.

2. That such tribunal shall have power to decide on the granting of patents, but it shall be open to inventors to renew their applications notwithstanding previous refusal.

3. That the said tribunal should be formed by a permanent and salaried judge, assisted when necessary by the advice of scientific assessors; and that its sittings should be public.

4. That the same tribunal should have exclusive jurisdiction to try patent causes, subject to a right of appeal.

5. That the jurisdiction of such tribunal should be extended to the trial of all questions of copyright and registration of design.

6. That the scientific assessors for the trial of patent causes should be five in number (to be chosen from a panel of thirty to be nominated by the Commissioners of Patents) for the adjudication of facts, when deemed necessary by the judge or demanded by either of the parties.

7. That the right of appeal should be to a court of the Exchequer Chamber, with a final appeal to the House of Lords.

8. That for the preliminary examination the assessors (if the judge requires their assistance) should be two in number, named by the Commissioners of Patents from the existing panel; the decision to rest with the judge.

9. That the committee approve of the principle of compelling patentees to grant licences, on terms to be fixed by arbitration, or in case the parties shall not agree to such arbitration then by the proposed tribunal, or by an arbitrator or arbitrators appointed by the said tribunal."

It will be observed that the resolutions of the committee relate, with the exception of the last one, entirely to the appointment of a special tribunal, for the preliminary examination of inventions, and for the trial of patent causes. The preliminary examination is the point of most importance, but it appears to us that the resolutions of the committee suggest very inadequate provision for such a preliminary examination as would be required. A single tribunal, however constituted, would be incapable of disposing of half the cases that would be brought before it. The present applications for patents average ten daily, and if the novelty of the invention, as well as its ingenuity and probable utility, are to be considered, and the objections of opponents are to be heard, it would be impossible to dispose of more than four or five cases in one day. It would be necessary also to have numerous permanently appointed examiners to search the patent records, before the claims to novelty could be satisfactorily established, and their reports might be open to objection, and give rise to long discussions. The time of two judges, with assistant assessors, would thus be fully occupied in the preliminary investigations, without allowing an hour for the trial of patent causes. The proposition to hear the claims publicly would, we believe, be strongly objected to by inventors, for their secrets would thus be exposed, and might be used to their prejudice in case a patent should be refused. The necessity for previous reference would, indeed, render it almost essential that the preliminary investigation should be conducted privately and confidentially, and after the inventor had established his claims to the satisfaction of the assessor appointed to examine them, the opinion of that officer might be publicly given, on the understanding that it would be confirmed unless reason were shown to the contrary. An arrangement like that, would, we conceive, be satisfactory to all applicants for patents, and it would at the same time give any competing inventor a fair chance of having his claim examined.

The incompetency of jurors to decide questions which require scientific or mechanical knowledge, renders it most desirable that some more fitting tribunal should be established for the trial of patent cases, and the one proposed by the committee would fully answer the purpose. We object however to the proposed right of appeal, for unless the judge or assessors be chargeable with partiality or prejudice, the Exchequer Chamber, and still less the House of Lords, could not determine such questions with an equal chance of arriving at a just conclusion. Justice delayed or dearly bought becomes injustice; and to give the power of appeal would perhaps place a poor inventor at the mercy of a rich invader of his rights, and be the means of inflicting grievous wrong, far more heartrending and injurious than open robbery, because inflicted under the cloak of the law.

The objection to giving protection to inventors, founded on the ground that such monopoly obstructs the progress of other inventions, would be completely obviated by an arrangement based on the last resolution agreed to by the committee on patents. It is contrary to the principle on which a patent is bestowed that the patentee should refuse to grant licences on reasonable terms, for it is expressly stated in the letters patent, as the inducement for granting them, that the petitioner conceives his invention will be "*of great public utility*," and that "we, being willing to give encouragement to all arts and inventions which may be *for the public good*, are graciously pleased to condescend to the petitioner's request." It is also an express condition that if it be made to appear "that this our grant is contrary to law, *or prejudicial or inconvenient to our subjects in general*," the letters patent shall be "utterly void." It appears, therefore, that the terms on which protection to an invention is granted provide for the removal of such obstruction to subsequent inventions as Sir William Armstrong complains of; but it must be admitted that, practically, owing to the cost and uncertainty of legal proceedings, patentees might, and sometimes do, throw difficulties in the way of improvement, in direct contravention to the conditions on which their patent rights were granted. The establishment of the means of readily and at little cost compelling patentees to grant licenses on reasonable terms,—consideration being had to the condition that the validity of their patents depends on public utility—would be a valuable improvement in the administration of the patent laws. It was indeed contended by Mr. Webster that it is the administration of the existing system, and not the system itself, that requires amendment; but it is well known that the ordinary legal tribunals afford no redress in the great majority of cases, and that the terrors of the law are much more effective in screening injustice than in protecting right.

As public utility is the basis on which patent rights are founded, if it can be proved that any protected invention is useless or prejudicial, the protection should cease. But at present such proof is difficult to be established, in consequence of the incompetency and costliness of the existing tribunals. Hence the necessity of other courts especially adapted to consider cases depending on the application of scientific principles, and in which justice may be obtained by the poor inventor as well as by the capitalists. This is the more necessary, in consequence of the present reckless system of granting patents without previous examination of the inventions; but if the amendments proposed by the patent law committee were efficiently carried out, all reasonable objections to patent rights would be removed.

◆

VENTILATION OF DWELLINGS AND HOSPITALS.

(*Continued from p.* 219.)

In our former notice of this subject we mentioned the authorities to which it was our desire to draw attention, and advanced so far in an account of the improvements lately introduced into our barracks—the dwellings of the soldiery—as to give the bare outline of the system adopted for them: a system contemplating for the removal of vitiated air two or more outlets from each room, one being the chimney flue, and the other or others being an outlet-shaft or shafts, constructed for the purpose; and providing for the supply of the requisite fresh air two or more inlets, one bringing in external air through a chamber contiguous to the fire-grate where it may become partially warmed, and the remaining one or more inlets being simply openings for external air of the natural temperature.

Before considering the subject of the ventilation of rooms in ordinary dwelling-houses, it will be desirable to give some of the details of the simple arrangement just referred to, as adopted by the Commission in the ventilation of barrack-rooms. To commence with the outlet shafts:—those introduced into the barracks operated upon by the Commission were, it must be recollected, additions to existing buildings in which no such system had been contemplated or provided for. In new buildings such shafts should be introduced during the erection, and should be made of glazed tubular tiles, as the smoothness of the inner surface is of great importance. The shafts made for the Barrack Commissioners were of 1-inch deal, planed smooth inside, and rebated at the angles, and were carried from one angle of the ceiling to 3 or 4 feet above the roof, and protected by louvres to prevent the rain beating down them. As the length of these shafts increases, the velocity with which air moves through them also increases, so that the sectional area of shaft necessary for rooms low down in the building is proportionately less than that needed for rooms on the upper floors.

> "In rooms on the top floor of a barrack we recommend shafts with a sectional area of 1 inch to every 50 cubic feet of room space; for the floors next below the upper floor a sectional area of 1 inch to 55 cubic feet of room space; and where the barrack consists of three floors, we have required for the lower floors a sectional area of 1 inch to 60 cubic feet of room space."

The theoretical velocity of the air leaving by any vertical outlet would be determined by the following formula:—

$$V = 8{\cdot}024\,\sqrt{H\,a\,(t - t')}.$$

V = velocity in feet per second; H = height of shaft; t = temperature of room; t' = temperature out of doors; a = coefficient of dilatation of air for 1° F. ·002. It is consequently obvious that the actual velocity of air in the shaft will vary constantly with the varying temperature of the external air, and it is consequently of great importance to supply outlets sufficient in number and area to change the air of the room to which they are applied during weather such as we often experience in this country, when the external temperature is high, and yet the air is so humid or the rain so decided as to render the opening of windows undesirable.

"The friction in the shaft, and the freedom or otherwise with which the air to supply the shaft enters the room," are pointed out as circumstances affecting the uniform action of such appliances; the escape will also be retarded if there be any difficulty at the outlet—that is to say, if the contained air be compelled to encounter obstructions at its exit from the shaft, or be exposed to the force of an opposing current of cold wind. All these considerations point out the necessity of providing an ample amount of exit, and also, as far as possible, of stimulating the escaping current. The syphon, to which we shall advert hereafter, is often a very efficient means of securing this last-named desideratum; and is worthy of more extensive adoption than it has received. Some means should also be provided for regulating the exit, without which in very cold weather, when the difference in temperature between external and internal air becomes very great, the flow would be too rapid, and consequently the amount of fresh air passed through the flue too great for comfort. In all cases in which these flues were adopted by the Barrack Commission means were provided for diminishing their openings by the introduction of a valve at the lower extremity of each flue.

Of the action of the fire on the air contained in a room we hardly need say anything; a large amount of air is drawn to feed its combustion, and, deoxygenised, passes up the chimney, while the current so created draws with it an equal—often a greater—amount of air which is not required to feed the flames, and passing above the fire enters the flue of the chimney. To supply this constant demand, and to replace the air which it is necessary should escape through the outlets, there is need of a constant influx of external air. This influx is commonly provided, in rooms of ordinary dwelling-houses, where the chimney flue or valve or syphon communicating with it forms the only outlet, by the small crannies and apertures in and about the doors and windows, and this source of supply being situated in parts of the room not so usually occupied as other portions, and being moreover spread over a comparatively extensive surface, is not often attended with serious inconvenience, though in large rooms it is not always—perhaps not often—sufficient.

Fig. 1.

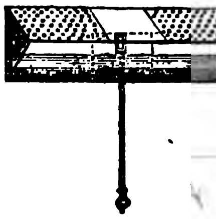


Fig. 2.

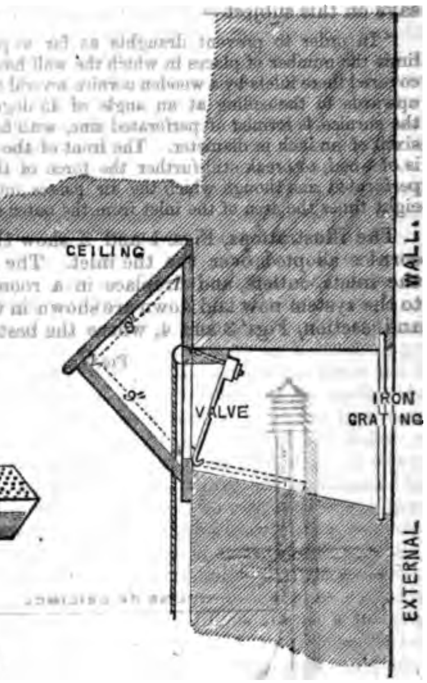
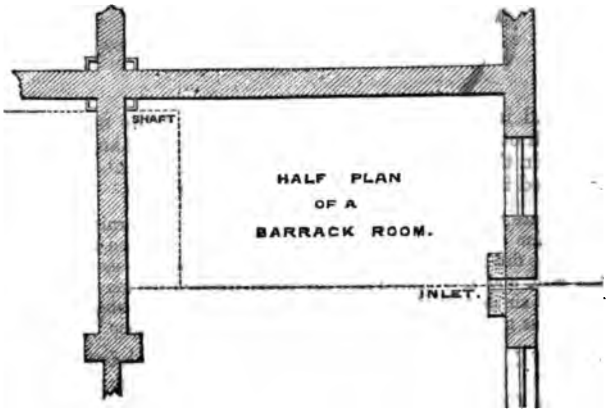


Fig. 3.

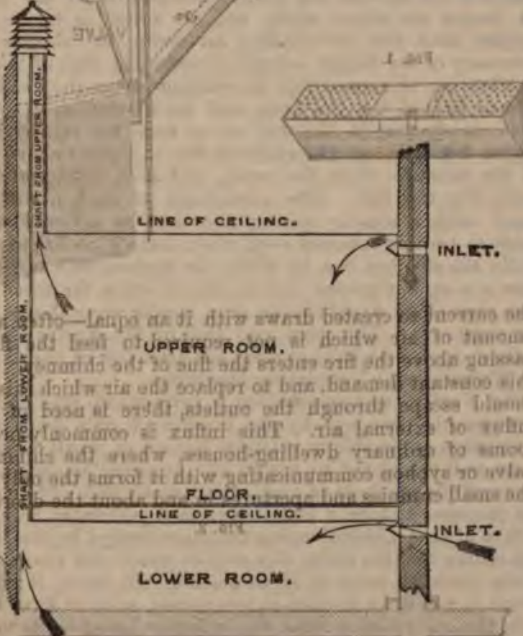


When however an outlet-shaft is provided, up which a portion of the products of respiration are expected to ascend in consequence of the rise in their temperature, it becomes imperative that some distinct and sufficient inlet for fresh air should be at the same time established; otherwise the chimney flue will, in all probability, overpower the less vigorous current which ought to occupy the shaft, and will convert what ought to have been an outlet-shaft into an inlet shaft for fresh air. Inlets were, in the case of the barrack-rooms, in all instances placed at or near the ceiling; their sectional area was, as remarked above, 1 square inch to every 50 or 60 cubic feet of air in the room,—though, if air were also admitted round the fire-grate, 1 square inch of the inlet to 120 cubic feet of space was considered sufficient. Generally two or more were introduced into each room. The report says on this subject—

> "In order to prevent draughts as far as practicable, as well as to limit the number of places in which the wall has to be cut away, we have covered these inlets by a wooden cornice several times their length, sloping upwards to the ceiling at an angle of 45 degrees. The upper side of the cornice is formed of perforated zinc, with holes of one-eighth to one-sixth of an inch in diameter. The front of the cornice opposite the inlet is of wood, to break still further the force of the current. The area of perforated zinc though which the air passes into the room is from six to eight times the area of the inlet from the outer air."

The illustrations, Figs. 1 and 2, show the form of ventilating cornice adopted over the the inlet. The general disposition of the inlets, outlets, and fireplace in a room ventilated according to the system now laid down are shown in the accompanying plan and section, Figs. 3 and 4, where the best relative positions for outlet and inlet are shown—namely, positions the most remote from each other, so as to promote as complete a change of air as possible in the room. Fig. 5 shows the arrangements as actually introduced into a room at the Wellington barracks.

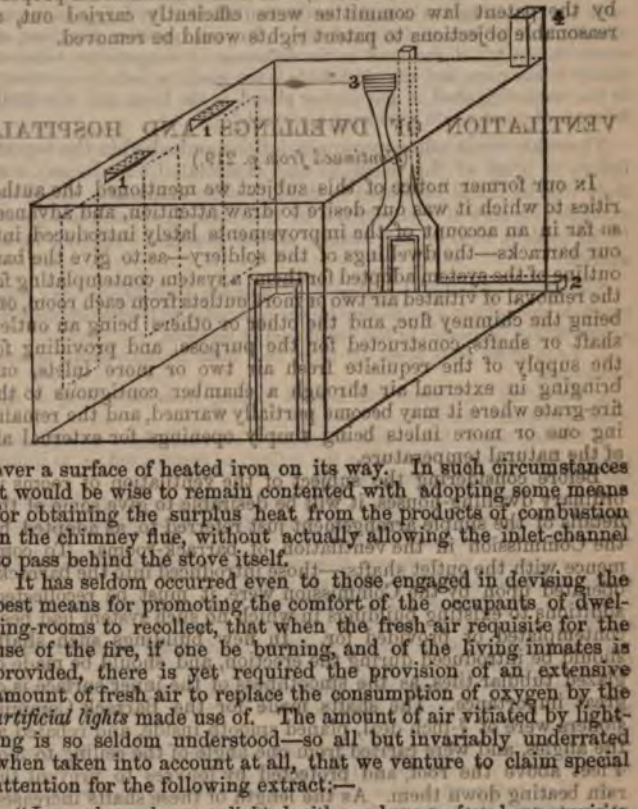
Fig. 4.



> "1, 1, are the cold-air inlets, protected by wooden cornices with perforated zinc covers. 2, is an inlet for air to be warmed in the space behind the fire-grate, which air, after being warmed, passes up the flue in the wall, and is admitted into the room through the louvres, 3. The outlet foul-air shaft is at 4. But in practice this outlet shaft should be placed at as great a distance as possible from the fire-place."

The only portion of the scheme which we have not now noticed is that which relates to the fire-grates, and the mode of heating a portion of the external air admitted into the room by letting it pass behind them. To discuss the form of fire-grate best fitted for adoption in any particular position hardly falls within the limit of our space—and we are not sure that anything short of the practical test of the use of a grate during a considerable period will suffice to enable an exact judgment to be formed of its merits. The form proposed for adoption in barracks seems open to the objection that the surfaces inclosing the chamber in which air is to be heated before it enters the room are of iron, and consequently when raised to a high temperature will exercise a deleterious influence on the quality of the air introduced. This is a point sedulously to be guarded against, and in small rooms where only one inlet was needed it would be very undesirable indeed to allow the whole supply of in-coming air to pass over a surface of heated iron on its way. In such circumstances it would be wise to remain contented with adopting some means for obtaining the surplus heat from the products of combustion in the chimney flue, without actually allowing the inlet-channel to pass behind the stove itself.

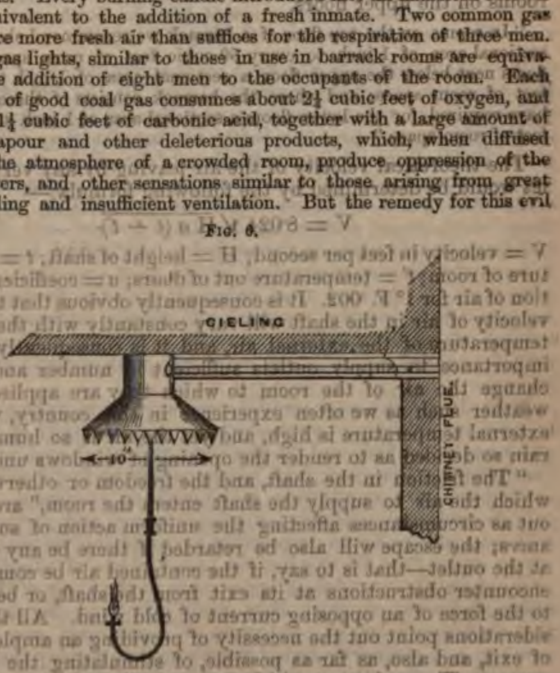
Fig. 5.



It has seldom occurred even to those engaged in devising the best means for promoting the comfort of the occupants of dwelling-rooms to recollect, that when the fresh air requisite for the use of the fire, if one be burning, and of the living inmates is provided, there is yet required the provision of an extensive amount of fresh air to replace the consumption of oxygen by the *artificial lights* made use of. The amount of air vitiated by lighting is so seldom understood—so all but invariably underrated when taken into account at all, that we venture to claim special attention for the following extract:—

> "In no barrack room lighted with gas have we found any provision for ventilating the gas burners. This absence of gas ventilation has, no doubt, in many cases added seriously to the impurity of the air in barrack rooms. Every burning candle introduced into an inhabited room is about equivalent to the addition of a fresh inmate. Two common gas jets require more fresh air than suffices for the respiration of three men. Two fan gas lights, similar to those in use in barrack rooms are equivalent to the addition of eight men to the occupants of the room. Each cubic foot of good coal gas consumes about 2½ cubic feet of oxygen, and produces 1¼ cubic feet of carbonic acid, together with a large amount of watery vapour and other deleterious products, which, when diffused through the atmosphere of a crowded room, produce oppression of the vital powers, and other sensations similar to those arising from great overcrowding and insufficient ventilation. But the remedy for this evil is simple enough: an ordinary ventilating shaft, if not too far from the gas burner, effectually removes the products of combustion, while the heat of the gas increases the draught of the shaft. Hence, in ventilating the rooms we have also ventilated the gas burners. Where however the distance between the burner and the shaft has been too great, and there

Fig. 6.



> has been danger of the foul air becoming diffused through the atmosphere of the room, we have had the burners ventilated separately by a ventilating funnel and tube of the common form (Fig. 6) to convey the products of combustion into the chimney, an arrangement which not only removes the products of combustion from the gas burner, but improves the ventilation of the room. The hot air from a gas light may also be used for increasing the draught in the foul air flue, by being conveyed directly to it by means of a metal tube. In some peculiar situations, or where the length of the shaft or the difference of temperature between the air in the room and the air outside is too small to occasion a current in the ventilating shaft, a gas burner placed at the lower end of a shaft becomes of great use in producing a current."

There are some other recommendations embodied in the report before us (that of the Barracks and Hospitals Commission), but they will be found indicated in the following summary, which we extract as a sort of counterpart to the statements already given by us (*ante* p. 219) of the nature of the problem required to be solved.

> "*Summary of Principles adopted in Barrack Ventilation.*—We shall conclude this subject by summing up the principles we have recommended as practically applicable to the ventilation of barracks.
>
> 1. Ventilating each room by itself, and quite independently of any other room.
> 2. Providing each room with a shaft passing from the ceiling of the room up through the roof.
> 3. Closing up all inlets near the floor, where such have existed, and placing the inlets for air close to the ceiling, so constructed as to insure the diffusion of the inflowing current.
> 4. Remodelling the barrack room grates and providing a chamber behind, for heating fresh air drawn from without, to be introduced warm above the level of the men's heads.
> 5. Ventilating all passages, staircases, and corridors by shafts and perforated panes independently of the rooms.
> 6. Providing as nearly as possible 1200 cubic feet of fresh air per man per hour, in a room space of 600 cubic feet per man.
> 7. Ventilating guard rooms by shafts, and remodelled grates for warming the air admitted.
> 8. Ventilating libraries, school rooms, reading rooms, and cook houses situated in the same houses as the barrack rooms, on the same principle as barrack rooms.
> 9. Ventilating non-commissioned officers' rooms, canteen tap-rooms, &c., by Arnott's ventilators and perforated panes.
> 10. Ventilating all stables under barrack rooms by shafts from the ceilings carried above the roof, and by inlets for air.
> 11. Providing for the ventilation of all gas burners in the way mentioned
> 12. We have recommended that ventilating and warming, together with the other sanitary arrangements of barracks, be placed in charge of some officer responsible for their efficiency."

We have dwelt thus at length on the ventilation of barracks, because those structures present almost all the difficulties with which we have to cope in the ventilation of ordinary dwellings —the subject more properly before us; because they will furnish many illustrations of the ventilation of hospitals, to which we purpose hereafter devoting some space; because our barracks presented the same condition when the Commission approached them which 99 per cent. of our dwellings do now—viz. they were buildings erected without any regard to ventilation, and required to have the deficiency supplied by the best expedient possible; but above all, we have thus enlarged upon the Barrack Report because it contains very practical and simple statements on the subject of ventilation, and unfolds a system applicable and actually applied to ordinary buildings, with every prospect of success.

Most dwelling-houses require some appliances to be adopted—at least in the living rooms—for the proper supply of fresh air and removal of foul, and in the arrangement of such appliances the general system just laid before us will be found safe, and, if carried out with intelligence and prudence, successful. Modifications may and probably will be required, and particularly it will generally be found impossible to adapt the vertical extracting or outlet flues for any but the upper rooms of existing dwelling-houses; their unsightly appearance in the angle of the rooms above those out of which they would open, and the probability that they would act as conductors of sound from one room to another, will ordinarily forbid the attempt to employ them. Accordingly we find the most successful expedients for extracting air from ordinary rooms are openings which draw it off at or near the level of the ceiling, and introduce it into the chimney flue. Among these we may enumerate Arnott's valve, the syphon, the perforated cornice of Varley, and the gas ventilator described above. Other self-acting methods exist, by the use of which air can be extracted from rooms, but they are ordinarily inapplicable in cases where a simple extracting shaft is inadmissible, and where that can be introduced it supersedes the use of any other means. Methods not self-acting we may at once dismiss, as being inapplicable for use in dwellings, and, to say the least, more or less undesirable under all circumstances and in all sorts of buildings.

Arnott's valve is now well known: it is fixed in an aperture communicating between the room and the chimney flue, at or near the level of the ceiling, and consists of a metal frame in which a small light valve works, calculated to admit air escaping from the room, but to obstruct any current setting into the room from the chimney. Where a sufficient supply of fresh air is provided, and where the lower opening of the chimney flue is not too large, this valve answers well, but it is liable, if these conditions are not complied with, to admit smoke into the room in place of drawing off vitiated air.

A syphon-shaped outlet for the vitiated air from rooms formed the subject of a patent long since expired, and has been recently again introduced to notice. The action of it is exactly similar to that of an ordinary syphon, only reversed; a common syphon conveys fluids heavier than the surrounding air from place to place, and in it the gravity of the fluid in the longer leg overcomes the weight of the shorter column in the other leg, and causes it to ascend till it reaches the bend. A syphon for extracting warm air from a room must be in an inverted position, its shorter leg going downwards to the bend, and its longer one rising again, and its action is to draw a fluid lighter than the surrounding air down the shorter leg, the buoyancy of the longer column overcoming that of the shorter. In adapting this apparatus to common rooms the bend is placed near or behind the fire-grate and the shorter leg descends to it from an opening in the wall at or near the ceiling, while the longer leg rises up the chimney flue to a point above the level of the entrance from the room, and then discharges its contents into the flue. The advantages of such a tube as compared with a simple opening are, that its action is not easily liable to become reversed even when there is no fire in the grate, while the smallest fire, by filling the syphon with rarefied air, at once sets up a vigorous and sustained action far more energetic than that of an Arnott valve or a simple vertical escape flue of the same area. This plan, and that of Mr. Varley about to be noticed, appear to have escaped the attention of the Commission on Warming and Ventilating Dwellings.

Mr. Varley's system received a prize which was offered some considerable time ago by the Society of Arts for a system of ventilation applicable to existing houses, at small cost; and appears well calculated to supply the required amount of air, and carry off the products of respiration easily and without draught. He proposed to form a hollow cornice of perforated zinc, by fixing a strip of that material across the angle formed by the junction of the ceiling and the walls; this cornice was to run round the whole of the room, or parts of it, as desired; but when it ran entirely round it was to be divided at two points, so as to form two channels, the one running near the chimney being made to communicate by an opening with the chimney flue, and the other half having an opening leading into it which communicated directly with the external air. The action of these two openings is of course that the one shall draw off vitiated air and the other supply fresh; and it is stated that if only the precaution be adopted of omitting or closing up the perforations exactly opposite the two points where channels open into and out of this hollow cornice, the perforated zinc will be found to equalise and distribute the incoming and outcoming currents, so as to avoid risk of draught.

Of the ventilation of gas burners much more need not be said than has been in the extract above given. In ordinary dwelling-rooms it is most desirable to ventilate gas burners, and as the hot air from them is given off at a very high temperature, the current will be really very strong; and consequently, if the opening be of sufficient size, and not too much cut off from surrounding space, the ventilation of a gas light may be easily made to create a sufficient current to cause the removal of all products of respiration from a crowded room.

(*To be continued.*)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

On the Effects of Vibratory Action and long continued Changes of Load upon Wrought Iron Bridges and Girders. By Wm. Fairbairn, LL.D., F.R.S.

(*With an Engraving.*)

It is upwards of fifteen years since a series of experiments was made to determine the value of wrought-iron riveted plates in the form of rectangular tubes, when employed as girders spanning rivers and ravines, for the support of roads and railways. Those experiments led to the erection of the Conway and Britannia Bridges, on the Chester and Holyhead Railway, and determined the form in which such structures should be designed, as also the strength necessary to resist the strain of the passing loads. A new theory of construction was thus developed, and a new era established in the history of bridges. Since that time some thousands of bridges, composed entirely of wrought-iron plates, have been erected, supporting roads and railways, with a degree of safety not attainable with any other description of material.

The construction of the Britannia and Conway Bridges of the tubular form led to the introduction of tubular, girder, plate, and various forms of lattice bridges, all founded on the same principle.

The tubular bridges were originally designed so that their ultimate strength should be six times the greatest rolling load which could be placed upon them after deducting the weight of the tube. This was considered a fair margin of strength, but subsequent considerations have induced in many cases an increase of this margin of resistance to five or six times the maximum rolling load and permanent load taken together.

Owing to the great success in the first examples of wrought-iron bridges, a great demand for them arose in every direction, and numbers were made without any regard to principle or the laws of proportion so clearly and satisfactorily developed in the Millwall experiments. The result of this was the erection of many weak bridges, so disproportioned as to be at the point of breaking with little more than double their own weight. This, together with the bad system of contractors tendering by weight, and the employment in some cases of *bad iron and bad workmanship*, have brought discredit upon the margin of strength at first considered sufficient. No construction requires greater care or a more minute attention to sound principles of construction than wrought-iron girders. The lives of the public depend on the knowledge and skill of the engineer, and the fidelity of himself and the contractors in the selection of the material.

The defective and abortive structures which followed the first successful application of wrought-iron led to doubts and fears on the part of some engineers, who contended for a margin of eight or even ten times the heaviest load, whilst others consider a much smaller surplus of strength sufficient. In the evidence given before the Commission on Railway Structures, in 1848–9, this variety of opinion was fully shown. Mr. Brunel allowed the maximum load to be one-third to two-fifths of the breaking weight. Mr. Grissell and Mr. May considered one-third sufficient; Mr. Rasbrick, Mr. Barlow, and others adopted one-sixth; Mr. Hawkshaw, one-seventh; and Mr. Glynn, one-tenth. Ultimately the authorities at Whitehall appear to have decided, but upon what data is uncertain, that the maximum tensile strain on any part of a wrought-iron structure, arising from the permanent load and the greatest rolling load together, should not exceed 5 tons per square inch. This corresponds with a strength of at least four times the rolling load and the permanent load taken together.

The requirement of 5 tons per square inch on the part of the Board of Trade appears to be founded on no fixed principle, and is far from satisfactory. It is well known that the powers of resistance to strain of wrought-iron depend very much upon the form in which it is combined, and, unless the proportions of the parts are permanently established, the 5 ton tensile strain may lead to error.

I have been led to inquire into this subject with the utmost care, not only on account of the imperfect state of our knowledge in this respect, but from the want of definite instructions from the authorities, whose business it is to secure the safety of the public, and enhance the value of these constructions. To accomplish this, I have in the following experimental researches endeavoured to arrive at the limit to which a girder may be strained without injury to its powers of resistance.

During the years 1858–9, I was engaged in the construction of a viaduct of 230 feet span, for the purpose of carrying the Inverness and Aberdeen Junction Railway over the river Spey. Concerning this viaduct an important discussion arose between one of the government inspectors of railways, Capt. Tyler, R.E., and myself, having reference to the margin of strength necessary to prevent disruption from the strain and vibration of the passing load. It has been thought by some that long-continued impacts ultimately destroy the cohesive properties of beams. In cases of extreme loads this has been proved to be the case, both in the following experiments and in the earlier ones of the royal commission. But it is very imperfectly known what fraction of the breaking weight, operating in a long series of changes, as a transverse strain, would in a given time absolutely lead to fracture. As the designs, calculations, and proportions of the superstructure of the Spey Bridge were entirely in my hands, I found myself responsible for the security of the structure. My original estimate of the strength of the bridge was—

Sectional area of top	120 sq. inches.
„ bottom	110 „
Depth of girders	16 feet.
Span of girders	230 „

Hence, for the centre breaking weight of one girder, we have, from the formula deduced from the experiments at Millwall:—

$$W = \frac{adc}{l} = \frac{110 \times 16 \times 80}{230} = 612 \text{ tons,}$$

and for the breaking weight of the bridge, with the load distributed, 612 × 4 = 2448 tons.

To this calculation the Board of Trade objected, on the following grounds:—That I did not deduct the area of the rivet holes in the bottom web. That I included two packing strips of a total area of 12½ inches, which, not having their joints covered, did no duty in strengthening the bridge. That the depth ought to be calculated between the centres of gravity of the top and bottom flanges, thus reducing *d* from 16 feet to 15 ft. 3 in. Lastly, that the constant 80 is too high for tubular girder bridges; 74·4 more nearly representing the results of the experiments. Capt. Tyler's data are therefore:—

Area of bottom	99 inches.
Depth	15 ft. 3 in.
Span	230 feet.

Centre breaking weight of one girder =

$$W = \frac{99 \times 15{\cdot}25 \times 74{\cdot}4}{230} = 488{\cdot}37.$$

Breaking weight of bridge, load distributed, = 488·37 × 4 = 1953·5 tons, or about one-fourth less than my own calculations.

With the exception of the objection as to the packing strips, however, I cannot consider Capt. Tyler's views correct. I do not deduct the rivet holes, because the formula is obtained from the gross area of the model tube, nor can I accept 74·4 as the proper constant for girders with cellular tops. But in calculating the strength of a bridge in which a proper ratio is preserved between the top and bottom areas, the constant derived from a similar case is, in my opinion, the most appropriate one to employ. It is manifestly unfair to use a constant derived from a beam of defective proportions, and composed, as is not unfrequently the case, of inferior iron. Again, however theoretically advantageous it may be to calculate the depth between the centres of gravity of the top and bottom flanges, it has been found sufficiently accurate hitherto to take the whole depth, if this has also been done in deducing the constant.

Making allowance for the absence of the covers over the joints of the packing strips, the strength of the Spey Bridge was not less than 2200 tons with the load distributed; and provided a further allowance were made for the thickness of the sides, it would bring the strength up to the original computation of 2448 tons.

But, in the consideration of the margin of strength, a more important difference arises between myself and Capt. Tyler. The permanent weight of the bridge between the abutments is 375 tons, and the weight of the platform 46 tons, so that the total permanent load is 421 tons. The maximum rolling load for a double line of rails was ultimately taken by Capt. Tyler at 408 tons, the weight employed by him in testing the bridge.

Capt. Tyler considers that the ultimate strength of the bridge ought to be four or five times the total maximum rolling load added to the total permanent load. That is, that the strength of the Spey Bridge should amount to 4100 tons, instead of 2448, which I had provided for in my calculations.

---

* Continued from page 309.

On the other hand, I have been accustomed to regard the permanent weight of the bridge and the rolling load as acting independently. From the breaking weight I deduct the permanent load, and consider the remaining resistance as the surplus strength for resisting the rolling load.

To both of these methods of calculating the margin of strength certain objections attach. With very small bridges they agree nearly with one another. With larger bridges, the method I follow gives weaker bridges than those desired by the government inspector. The larger the bridge becomes, the more rare are the occasions on which the rolling load is at its maximum. With very large bridges, equal in span to those over the Conway and Menai Straits, both lines can scarcely ever be loaded up to the limit of two tons per foot run. Now, the fault of the allowance of strength demanded by the Board of Trade appears to me to be, that it takes no account of this fact. It provides bridges which become increasingly strong in proportion to their work as the span is increased. Hence the Conway Bridge, strong and durable as it has proved itself, does not reach the margin of strength which the Board of Trade requires. In fact, in order to raise it to that standard, it must be increased to at least five times its present strength, since, with bridges of such span, every addition to the strength adds also in a high degree to the permanent weight of the bridge. It remains therefore to be considered how far the weight of bridges of large span acts by its inertia in antagonism to the rolling load.

On the other hand, the rule I have employed does appear to provide bridges which, in very large spans, are weaker in proportion to their work than in small spans. Within the limits ordinarily required, that is not exceeding 300 feet span, I have not found bridges so proportioned to offer any signs of weakness. The strength of the Conway and Britannia Bridges, although considerably in excess of six times the rolling load, is nevertheless much nearer to that than the proportion of five tons per square inch of section.

I have drawn curves showing the relations of strength, weight, and span which are given by the rules I have discussed, between the limits of 50 and 100 feet span (see Plate XXXIV). The dotted lines represent the ratio of the centre breaking weight of the bridge to its span, and the ratio of the permanent weight of the bridge to the span, whatever that may be. The black lines represent the same ratios according to my own rules.

These curves show—First, that for spans of less than 100 feet the Board of Trade rule gives weaker bridges than my own. Second, that in very large spans the Board of Trade rule gives bridges enormously stronger than my own. Third, that at or below [illegible] feet of span the limit is reached at which it is practically possible to erect tubular girder bridges of the same proportions as those across the Conway or Menai Straits, in which the maximum strain does not exceed the Board of Trade standard. The reason of this is the high ratio in which the weight of the bridge increases in large spans. In fact, the weight increases as the cube, whereas the strength increases as the square of the lineal dimensions.

The above considerations have led me to experiment upon the influence of vibration in causing the rupture of beams and bridges. For this purpose I have constructed a small wrought-iron [illegible] beam, of [illegible] feet clear span and [illegible] inches deep, representing the proportions of one of the girders of the Spey bridge, [illegible] similar to those of a bridge subject to [illegible] load and vibration, as produced by the passage of [illegible] the beam [illegible] rolling load. The proportions of the beam are as follows:

[illegible]

This beam having been fixed securely, as will be seen by reference to the illustration (see *C. E. & A. Journal*, vol. xxiii. p. 257), the experiments were commenced. In the woodcut referred to, A is a shaft and pulley driven by a water-wheel; B a wheel and pinion giving motion to the connecting rod C, which lifts the end of the lever and load from off the beam, shown in section at D, with the shackle and clip *a*. At the lower end of the connecting rod C is a slot, made for the purpose of allowing the load to come fairly upon the beam before the next suspension: E is the lever, and F the scale, for regulating the weight. On the top flange of the beam was stretched a gauge to ascertain the deflections during the changes and vibrations produced by the different loads. By means of a water-wheel the continual lifting and releasing of the lever was continued night and day, and the number of changes of load was registered by a counter at D.

The experiments were commenced by loading the beam to within a fourth of its breaking weight, and starting the apparatus. After more than half a million of changes of load the beam appeared to have sustained no injury.

TABLE I. *Beam loaded to one-fourth of its breaking weight.*

Total moving load	5809 lb.
Permanent load (or half weight of the beam)	434 lb.
Margin of strength by Board of Trade ...	3·4 to 1.
Strain on bottom flange	4·35 tons per sq. in.

Date.	Number of changes of load.	Deflection at centre of beam.	Date.	Number of changes of load.	Deflection at centre of beam.
1860.			1860.		
March 21	...	0·17	April 13	268,328	0·17
22	10,540	0·18	14	281,210	0·17
23	15,610	0·16	17	321,015	0·17
24	27,840	...	20	343,880	0·17
26	46,100	0·16	25	390,430	0·17
27	57,790	0·17	27	408,264	0·16
28	72,140	0·17	28	417,940	0·16
29	85,960	0·17	May 1	449,280	0·16
30	97,420	0·17	3	468,6[illegible]0	0·16
31	112,810	0·17	5	489,769	0·16
April 2	144,350	0·16	7	512,181	0·16
4	165,710	0·18	9	536,375	0·16
7	2[illegible]2,890	0·17	11	5[illegible]0,529	0·16
10	235,811	0·17	14	5[illegible]6,799	0·16

The beam took at first a permanent set of about 0·01 inch. which did not appear to increase afterwards. The beam was then subjected to experiment with an increased load, equivalent to one third the breaking weight.

TABLE II. [illegible] to one-third of its breaking weight.

Total moving load	[illegible] lb.
Permanent load	434 lb.
Margin of strength by Capt. Tyler's rule	[illegible] to 1.
" " my own rule ..	[illegible] to 1.
Strain on bottom flange	5·47 tons per sq. in.

Date.	Number of changes of load.	Deflection at centre of beam.	Date.	Number of changes of load.	Deflection at centre of beam.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

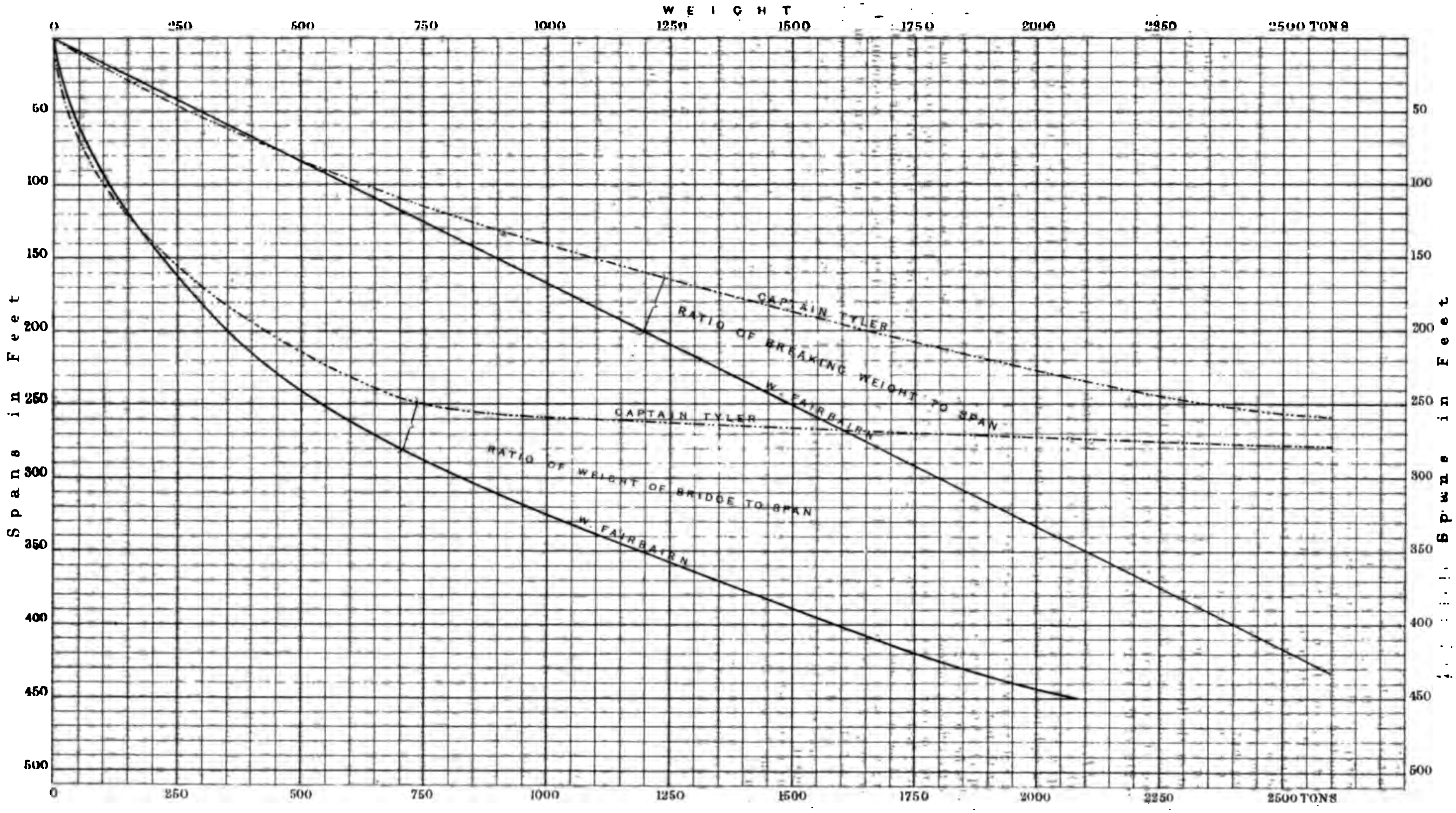
The beam had now [illegible] partly with a load [illegible] and partly with a load of [illegible] the breaking weight. As it was [illegible] was increased to nearly [illegible] breaking weight. See [illegible]

With a load [illegible] the breaking weight the beam gave way after [illegible] It appears therefore that it is [illegible] the rolling load bears its [illegible] proportion to the breaking weight.

RATIO OF BREAKING WEIGHT, WEIGHT, AND SPAN OF

TUBULAR GIRDER BRIDGES

ACCORDING TO THE FORMULÆ OF THE BOARD OF TRADE AND W. FAIRBAIRN, C.E. LL.D. F.R.S



Novr 1867.

J.R.Jobbins

Table III.—*Load equivalent to one-half the breaking weight.*

Total moving load	...10050 lb.
Permanent load	... 434 lb.
Margin of strength by Capt. Tyler's rule ...	2·05 to 1.
" " my own rule ...	2·09 to 1.
Strain on bottom flange	7·32 tons per sq. in.

Date.	Number of changes of load.	Deflection in inches.	Remarks.
1860.			
June 27	......	0·35	
28	5175	......	The beam broke.

The beam was then taken down and repaired; a patch was riveted across the fracture in the bottom plate, so that the area of the sound plate remained as before. The experiments were then renewed: 158 changes of load were sustained with a load equivalent to one-half the breaking weight. The load was then reduced to two-fifths the breaking weight, and 25,900 changes of load were sustained. Lastly, the load was reduced to one-third of the breaking weight, and the results given in the following table were obtained:—

Table IV.—*Load equivalent to one-third of the breaking weight.*

Total rolling load	... 6359 lb.
Permanent load	... 434 lb.
Margin of strength	... 3·2 to 1.
Strain on bottom flange	4·74 tons per sq. in.

Date.	Number of changes of load.	Deflection in inches.	Date.	Number of changes of load.	Deflection in inches.
1860.			1860.		
Aug. 13	25,900	0·18	Dec. 22	929,470	0·18
16	46,326	0·18	29	1,024,500	0·18
20	71,000	0·18	1861.		
24	101,760	0·18	Jan. 9	1,121,100	0·18
25	107,000	0·18	19	1,278,000	0·18
31	135,260	0·18	26	1,342,800	0·18
Sept. 1	140,500	0·18	Feb. 2	1,426,000	0·18
8	189,500	0·18	11	1,485,000	0·18
15	242,860	0·18	16	1,543,000	0·18
22	277,000	0·18	23	1,602,000	0·18
30	320,000	0·18	March 2	1,661,000	0·18
Oct. 6	375,000	0·18	9	1,720,000	0·18
13	429,000	0·18	13	1,779,000	0·17
20	484,000	0·18	23	1,829,000	0·17
27	538,000	0·18	30	1,885,000	0·17
Nov. 3	577,800	0·18	April 6	1,945,000	0·17
10	617,800	0·18	13	2,000,000	0·17
17	657,500	0·18	20	2,059,000	0·17
23	712,300	0·18	27	2,110,000	0·17
Dec. 1	768,100	0·18	May 4	2,165,000	0·17
8	821,970	0·18	11	2,250,000	0·17
15	875,000	0·18	June ...	2,727,754	0·17

The following table gives a summary of the results obtained in this series of experiments:—

Table V.—*Summary of Results.*

Experimental table.	Load at centre.		Ratio of load to breaking weight.	Tensile strain on bottom.	Strain on bottom, after deducting rivets.	Changes of load.	Deflection.	Remarks.
	Changing.	Weight of beam or permanent load.						
	lb	lb		Tons.	Tons.		Ins.	
I.	5809	434	3·4 : 1	4·35	5·91	596,790	0·17	Uninjured.
II.	7406	434	2·7 : 1	5·47	7·43	403,210	0·23	Uninjured.
III.	10050	434	2·05 : 1	7·32	9·92	5,175	0·35	Broke.
IV.	6359	434	3·2 : 1	4·74	6·42	2,727,754	0·17	Uninjured.

In using the numbers giving the strain in tons per square inch of the gross sectional area of the bottom, it must be remembered that a larger proportion is punched out for the rivet holes in this small beam than in bridges. Taking the next column, which gives the strain on the metal of the bottom after deducting the rivet holes, we find that the beam suffers no deterioration with strains of nearly 7½ tons per square inch. With 10 tons per square inch the beam broke after 5172 changes of load. Now, as the limit of elasticity is reached at about 9 tons per square inch in ordinary boiler plates and bridge plates, it would appear that it is unsafe to load structures subject to a continually varying load beyond that point. Within these limits however we have no evidence that a deterioration of the structure takes place.

The results given here apply chiefly to cases where nearly the whole load of the beam is a changing load, the weight of the beam itself being insignificant. It remains to be considered in the case of large bridges, where the chief part of the load is permanent and stationary, and the lesser portion only changes, whether even greater strains than these would not be suffered with impunity. On this subject we have no experiments which apply to wrought-iron, but in the case of cast-iron some results have been obtained which have an importaant bearing on the question.

In the first place I have shown that where the whole load is permanent and stationary, cast-iron bars loaded with three-fourths of the breaking weight suffer very slight deterioration in the course of time. Thus, in the experiments recorded in the "Report on the Effect of Time on Loaded Cast-iron Bars," published in the Transactions of this Association, it was shown that the increase of deflection of bars loaded with three-fourths of their breaking weight amounted in the course of five years to 0·004 inch in the case of cold-blast iron, and to 0·009 inch in the case of hot-blast iron: that is, that there was a mean increase in five years of $\frac{1}{500}$ of the whole deflection of the bar. With a cold-blast bar loaded with above nine-tenths of the breaking weight the increase in four years was $\frac{8}{1000}$ of an inch, or not more than $\frac{1}{180}$ of the whole deflection. These experiments would seem to show that with a stationary load materials may be loaded with impunity within the limit of elasticity, or nearly up to a force calculated to produce fracture.

Secondly, in the case where part of the load changes and part is permanent, some experiments were made by the Commission on Iron Structures, which gave the following remarkable result. That additional loads spread uniformly over a beam increased its power of resisting impacts. They found that beams of cast-iron, loaded to a certain degree with weights spread over their whole length, and so attached as not to prevent the flexure of the bar, resisted greater impacts from the same body falling on them than when the beams were unloaded, in the ratio of 2 to 1. There is great difficulty in applying such results as these to the case of bridges of wrought-iron, but at least they may serve to indicate the direction which should be taken in further experimental inquiries on this very interesting and important subject.

On some future occasion I may have again to refer to this subject. For the present, I would advise that in all beams and girders, tubular or plain, the permanent load, or weight of the girder and its platform, should not in any case exceed one-fourth of the breaking weight. And that the remaining three-fourths should be reserved to resist the rolling load in the proportion of six to one.

As a general rule, these ratios of strength would apply to all bridges, but the strains would be least on the smallest bridges, which, in my opinion, is requisite on account of the frequency of neglect of smaller structures.

I would earnestly direct the most careful attention to the laws which govern the resisting powers of girders exposed to transverse strains; to the best principle of uniting the joints; and, above all, to the selection of the best material, which, in the parts of girders subject to a tensile strain, ought always to sustain a test of from 22 to 24 tons per square inch. There is no economy in the use of inferior iron for this purpose, and its employment inevitably leads to a loss of character in the structure, and danger to the public.

On a Bathometer, or Instrument to indicate the Depth of the Sea on board Ship without submerging a Line. By C. W. Siemens.

Those who are acquainted with the difficulties and expense attending the taking of deep-sea soundings by means of a weighted line, will readily perceive that an instrument capable of indicating depths upon a graduated scale in the cabin of the vessel would be of great advantage, as a means of extending our knowledge of ocean geography. In laying submarine telegraph cables through deep seas, such an instrument would be invaluable.

It occurred to the writer that the total attractive force of the earth must be sensibly influenced by the interposition of a comparatively light substance, such as sea-water, between the vessel and the solid portion of the earth below. This he demonstrated geometrically as follows:—Assuming the earth to be a perfect sphere of uniform density, two lines are drawn from a point on the surface, so as to intercept the circumference at the semicircles. A line is then drawn through the two points of intersection, which passes through the earth's centre, and a second line parallel to it, touching the circle at its lowest point. It was next demonstrated, that in dividing the solid cone represented by these lines into a number of slices of equal thickness, in a direction perpendicular to its axis, each slice would exercise the same amount of attractive force upon a body at the apex of the cone; the reason being that the mass of each slice increases in the proportion of the square of its distance from the apex, and the attractive force diminishes in the same ratio.

It was thus demonstrated that the true centre of gravity of the earth in reference to an attracted body on its surface does not reside in its geometrical centre, but in a variable point between the centre and the attracted body. In dividing the sphere itself into slices of equal thickness a mathematical expression was obtained, representing the attractive force of any of these slices; and in integrating this expression for a series of slices it was the following formula:—

$$A_1 = 2\pi h\left(1 - \frac{2}{3}\sqrt{\frac{h}{2R}}\right)$$

in which A_1 signifies the attraction of the piece of the sphere sliced off, h the depth of this piece, and R the radius of the earth. In substituting 2R for h, the formula gives the total attraction of the earth, $A = \frac{4}{3} R\pi$, agreeing with Newton's formula.

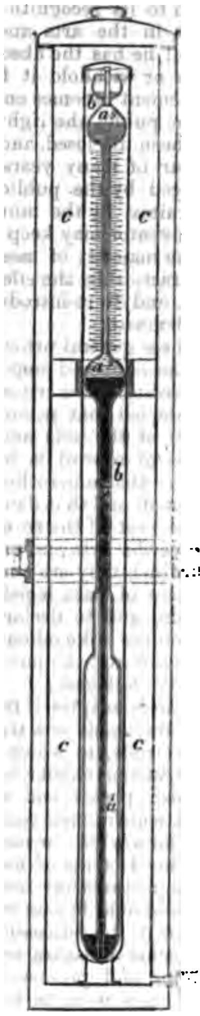
Considering that the depth of the sea, which is represented by h, is exceedingly small as compared to 2R, the expression $\sqrt{\frac{h}{2R}}$ may be entirely neglected, and the first formula may be written

$$A_1 = 2\pi h.$$

$$\text{Consequently, } A : A_1 = \frac{4}{3} R\pi : 2\pi h,$$

$$\text{or, } A_1 : A = h : \tfrac{2}{3}R.$$

For moderate depths the attraction of the earth may be represented by a very obtuse cone, with $\frac{2}{3}$R for its height. If sea-water were of no weight, the total attraction of the earth would be diminished upon its surface in the proportion as the depth to $\frac{2}{3}$R; but considering that sea-water has about one-third the weight (bulk for bulk) as the generality of rock, the actual diminution of gravitation was shown to take place in the proportion of the depth to the radius of the earth. Accordingly, 1000 fathoms of depth would produce a diminution by $\frac{1}{5900}$ part of the total gravitation, a difference so small, that it appears at first sight impossible to construct an instrument capable of indicating it with sufficient accuracy.



The second part of the paper described the instrument designed for this purpose, which consists of a tube containing mercury, diluted spirits of wine, and coloured juniper oil. The mercury column, about 30 inches high, ascends in a tube from the bottom of a large bulb a^1, containing imprisoned air, and terminates in the middle of a second bulb a^2. The remainder of the second bulb is filled with the diluted spirits, which reach upward into a narrow tube provided with a scale. Upon this rests a column of the coloured oil, which terminates in a third bulb a^3, the remaining space being vacuous, or nearly so. This gauge is inclosed in a glass tube b, b, filled with distilled water, which in its turn is surrounded with ice c, c, contained in an outer casing: the latter is suspended by a universal joint. The air in the lower bulb, being maintained in this way at a perfectly uniform temperature, will oppose a uniform elastic force against the column of mercury, which latter, being removed from all atmospheric influences, fairly represents the gravitation of the earth.

In moving this instrument from shallow water upon a sea of 1000 fathoms depth, the mercury column would rise $\frac{1}{1200}$ part of its length in the second bulb; but before any sensible attraction has taken place in the mercury level, the upper surface of the spirits of wine terminating in the narrow tube will have risen sufficiently to restore the balance of pressure, and the spirits being 20 times lighter than mercury the scale of observation would be increased twentyfold. But the spirit column, in rising, displaces oil of very nearly the same specific gravity, which causes another increase of scale at least twentyfold. By these means a scale of 3 inches per 1000 fathoms of depth is obtained.

An instrument of this description was tried by permission of the Admiralty, and although it was still imperfect in some respects, its indications agreed generally within 10 per cent. with the results of actual soundings.

In the course of the discussion which ensued, Prof. Tyndall suggested that the instrument would be equally applicable for measuring heights.

On some applications of Ebonite, or Hard India Rubber.

By H. A. Silver.

The material known as Hard India Rubber, Vulcanite, Horn Rubber, or in its most perfect condition as Ebonite, was first obtained by Hancock; although its discovery was also effected by the independent researches of Goodyear. Ebonite consists of india-rubber vulcanised with sulphur at a high temperature, which is continued for several hours. As in the case of caoutchouc or pure india-rubber, the applications of this material were until lately extremely limited. It is principally met with in the form of combs, paper-knives, and pen-holders; but its peculiar properties possessed render it available for far more important uses. Its acoustic qualities have been utilised in the construction of stethescopes, and render it well adapted for ear trumpets, for flutes, and several other wind instruments. Like horn or ebony, it may readily be turned in the lathe, although in practice it is found preferable to produce it in moulds of any desired form. It is a most powerful—probably the most powerful—negative ideo-electric; and from not being liable to fracture, it advantageously replaces the glass plates of electrical machines. From this fact, and from its possessing no hygroscopic attraction for moisture, it may be inferred that it is also an excellent insulator of electricity. Apart from its application in the form of insulators for overground wires, to which I have to direct attention in connection with the accompanying table, it is found most useful in the insulation of practical and philosophical electrical apparatus.

A recent and valuable application of ebonite is in the construction of "nitrate baths," and other apparatus for use in photography, and also for battery cells. In vessels of this material the nitrate of silver may, with suitable precautions, be boiled, without affecting the solution. This process is sometimes necessary, and cannot be performed in vessels either of glass or gutta-percha. The battery cells, indestructible in other respects, resist even the intense fluid heat produced by the addition of concentrated sulphuric acid of water. In a recent number of the *Photographic News*, Mr. M. A. Gandin calls attention to the prejudicial effect upon silver solutions of the tannin contained in the gutta-percha of which photographic vessels are now commonly made. The advantages offered by vessels combining the resistance to fracture of gutta-percha with the negative chemical properties of glass and porcelain, and capable of withstanding a temperature considerably above 212° Fahr. without danger of bulging or softening, will be duly appreciated by photographers.

In an ornamental point of view, ebonite has been used for covering articles of iron or steel, such as buckles for belts or harness; thereby rendering them unalterable by oxidation, and substituting an equally beautiful material for the metallic surface. It has been employed as an imitation of buckhorn handles for knives, and as a substitution for horn or ebony in buttons, napkin-rings, and various kinds of ornamental work. In the form of bracelets and similar ornaments it advantageously replaces jet, to which substance it bears great resemblance, without being liable to chip or fracture. It has also been used for mounting jewellery.

The table of comparative results obtained with glass, porcelain, brown ware, and ebonite insulators for overground wires, gives a few unselected tests from the lengthened series by which the great superiority of the last-mentioned material is established. It is to be observed that the surface of the glass, porcelain, and brown ware insulators consists of nearly the same substance—viz. an alkaline or earthy silicate, possessed of considerable hygroscopic properties, through which it allows of the passage of electricity by the conduction of the deposit of atmospheric moisture. Besides being in itself a better insulator, ebonite is free from the hygroscopic property which thus constitutes so serious an objection to the use of glazed insulators. The non-liability to fracture of the ebonite insulators is also an important advantage. It will be seen by inspection of the insulators constructed of wood and ebonite that the latter material is protected both from the direct rays of the sun and from rain. To those whose experience of overland telegraphy has rendered them familiar with the numerous causes which interfere with the efficiency of the apparently simple contrivances for pole insulation, the inspection of this insulator may prove of interest. Ebonite, like pure caoutchouc in the case of submarine wires, appears to be "almost specially intended" for the insulation of overland wires. The perfection of the means for obtaining the latter is a problem of sufficient importance to have induced me to offer these few brief observations on this subject; being one that is more within the limits of my own observation and experience than the kindred topic which now almost engrosses attention—the perfection of the means for securing telegraphic communications from shore to shore throughout the globe.

Table of Tests, showing comparative merits of Glass, Porcelain, Brown Ware, and Patent Ebonite Insulators.

The system composed of the above description of insulators fixed on seven poles, one of each kind on every pole, the whole covering 420 yards of marshy land.

Date, &c.	Description of insulator, and result.	Temperature. Fahr.	Elements.	State of weather.
1860. Dec. 29, 9 a.m.	Porcelain . 8° Glass . . 26 Ebonite . 0	17°	12	Dense fog; wires and insulators covered with frost.
Dec. 31, 8 a.m.	Porcelain . 14° Glass . . 33 Ebonite . 0	35	12	Great thaw, and foggy; everything damp where exposed.
1861. Jan. 5, 7 a.m.	Porcelain . 7° Glass . . 45 Ebonite . 0	32	4	Snowing and damp.
Feb. 4, 8 p.m.	Porcelain . 90° Glass . . 90 Brown ware 90 Ebonite . 0	40	90	Night fine.
Feb. 8, 9.45 a.m.	Porcelain . 67° Glass . . 67·5 Brown ware 90 Ebonite · 0·25	46	14	Thick and heavy.
March 12, 6.30 a.m.	Porcelain . 15° Glass . . 90 Brown ware 75 Ebonite . 0·50	...	90	Raining heavily, with much wind; had been raining all night.
March 30, 9.45 a.m.	Porcelain 297° Glass . 915·75 Br. ware 519·75 Ebonite . 2·25	...	354	Raining very heavily since 7 a.m.
March 30, 10.40 a.m.	7 Porcelain 36° 28 Ebonite 1·50	...	24	Fine—sun out; rain ceased since 10.25.

Note.—In the last experiment the number of porcelain insulators used was 7, the leakage 36°; whilst 28 ebonite insulators (7 each of four different shapes) were used, loss 1° 50′: it follows therefore that the escape in porcelain must be × by 4, which gives the following result:—

Loss in porcelain insulators	...	144°
Loss in ebonite insulators ...	...	1·50, or nearly 100 times less.

On Property in Inventions, and its effects on the Arts and Manufactures. By Thomas Webster, M.A., F.R.S.

To deny to the creations and labour of the mind that property and protection by the civil power which is given to the skill of the hand or to bodily labour, is, in effect, to make intellectual of no account as compared with physical labour; and to give a predominating influence to capital, and those other representatives of accumulated labour which may be profitably enjoyed without any fresh creation of mind or exercise of inventive faculties. Considerations of public policy have led to certain rules, laws, or regulations respecting the use and enjoyment of all property; property in lands and chattels may be enjoyed for the whole term of the natural life of the occupant, or by the family or successor of such occupant, but such successor is merely the creature of positive laws and public policy; and the commonwealth in allowing such succession, or affording by the arm of the law and civil power that protection which is essential to the very notion and existence of property in a civilised country, or wherever might does not constitute right, assigns in what manner such succession shall take place, or for what term the property should be enjoyed.

If occupancy and possession be the true principle to which the origin of property is to be referred, the inventor has a peculiar claim to its recognition, and claims in respect of any improvement in the arts and manufactures—the produce of his own brain; he has the absolute control of the invention; he may give it to or withhold it from the public: but so soon as such improvement becomes embodied in an art or manufacture accessible to the public, the right of exclusive possession is gone, the secret has been disclosed, and may be practised by anyone; and thus the labour of many years may be adopted by he who wills, and enjoyed by the public without remuneration or reward, unless restrained by the municipal laws of the country. To say that an inventor may keep his secret is to propound an impossibility in the majority of cases, and in the few cases in which it would be practicable, the effect would be to convert his art into mystery, and to re-introduce practices long since extinguished and condemned.

These general principles are not, as I understand, contravened by the supposed opponents of the patent system; the justice of rewarding the meritorious inventor is admitted. Further, it is not denied that patents may have been beneficial in the earlier stage of the arts and manufactures, but it is said that such a mode of reward is bad, and contrary to the principles of free trade—that some other system of rewarding the inventor should be adopted; and that dauntless spirit which, in matters of established trade, cast off the trammels of protection, is called upon to emancipate the arts and manufactures from the excess of protection by which they are borne down, and to correct the injurious tendencies of class legislation when opposed to general freedom of action, and to declare patents for inventions to be monopolies which are alike odious and injurious to the real interests of the inventor and the public. These views appear to me to involve several fallacies.

The principles of free trade, or of unrestricted competition, are not applicable to a trade which does not exist; the creation of a new trade, to which when created the principles of unlimited competition should be applied, is the object of protection for a limited period; and until such trade is created or established, that which exists cannot be the subject of any grant, which must be the working or making of some new manufacture.

The doctrine of *finality* cannot be recognised in the arts and manufactures any more than in political or social science; *progress* should be our watchword. Who will venture to assign any limit in the succession of improvements in the adaptation of the elements of nature or art to the requirements of man? The machines and processes of to-day are the elements out of which each new work is to be created; and whatever *may* be the exhaustion appearing to have taken place of mechanical elements and mechanical combinations, who can venture to assign any limit to the productive applications of light, heat, chemistry, and electricity. The mine of gravitation may have been well worked, but we are only just breaking the soil of those other wonderful agencies by which we are surrounded. It is the province of the philosopher to discover and to analyse what exists in nature, but it is the province of the inventor and of the manufacturer to recombine, create, and produce new forms and products.

It was said by Aristotle that there existed only three steps of continuance in art—namely, theory, contrivance, and production; this observation is equally applicable to manufactures resulting from mechanical skill: but it is the contrivance and production alone which can be the subject of property in patents; an idea, or that which is matter of theory only and not reduced to practice, cannot be the subject of letters patent. An idea must be embodied in some contrivance, and many of the objections to patents are founded on the attempts made by inventors, in which they are sometimes successful, to obtain property in that which is not legitimately the subject of invention. To permit this is a defect arising from the maladministration of the system; it is no objection to the system itself.

Let it not be supposed in making these observations that I am not deeply sensible of the many defects in our patent system. It cannot be denied that, in the language of Sir W. Armstrong, an excess of protection exists: the promoters of the reform resulting in the Patent Law Amendment Act, 1852, pointed out and predicted many of these defects, being deeply sensible of the inherent difficulties and probable defects of the system; but I do not hesitate to assert that a very large proportion of the objections made to the patent system and existing defects are due to the neglect of the precautionary measures provided in the act never having been taken.

If it is true that the public are suffering from an excess of protection, it is in great measure due to the non-administration of the system then established. It has been said that every inventor is compelled to be a patentee; but he may make a record of his invention at a small expense and no one else can patent it. The interest of the inventor is put forward as an objection to the present system, and it is suggested that he might be left to the gratitude and liberality of the employer in whose service he may be engaged. It would be a thankless task to recount the many instances within my own knowledge in which contests have arisen in the granting of patents between the workman and his employer; and if asked what portion of the new system was to be viewed with the greatest satisfaction, I should most unhesitatingly point to the power by which the artisan by a simple document of his own preparation may obtain provisional protection and inchoate rights, at a cost within his well-husbanded resources. The manufacturer who has a large capital embarked in an existing trade is not indisposed in the majority of cases to let well alone; he can hardly be expected to view with favour an invention which will leave him behind in the race of competition, unless by the abandonment of existing and the substitution of new machinery. The question of property in inventions is prominently a working man's question, and if there are bands of schemers who have to rue the day when they were drawn aside from their daily routine by the alluring prospects of invention, there are many in this city who can point to the patent system, with all its defects, as one of the rounds of the ladder by which they have been enabled to obtain and enjoy their present honourable position.

Whatever conclusion may be arrived at as to the benefit conferred on inventors as a class, and in the aggregate by the patent system, can any reasonable doubt be entertained as to its beneficial effects in stimulating progress in the arts and manufactures? It has been well described as a forcing system; the stimulus cannot be doubted, it is assumed and urged as an objection to the whole system.

An invention requires a careful training—it must be adapted to the requirements of the public, and the public must be prepared for its adoption; the process is one essentially of education. If such an education be necessary, how can it be attained but by enabling the parent to have that enjoyment of his property—use, so to speak, and service of his child for such a period as may be sufficient for the education of the child and the reward and remuneration of the parent. Instances illustrative of the above will crowd on the minds of all persons conversant with the progress of the arts and manufactures. Would the enormous capital in many cases essential to the creation of new trades have been applied if the experience so dearly bought could be adopted at the will and pleasure of another. But it is said, that in the advanced and rapidly-advancing state of practical science, that patents are obstructive, or in other words, that persons in carrying out their own ideas find they have been anticipated, and that they cannot run on a particular line without the consent or payment of toll to some prior occupant. That such an obstruction may exist cannot be denied, but the actual instances of such obstruction are more imaginary than real; it would be desirable that the instances should be cited, that the value and real nature of such obstruction should be estimated. The law admits of successive patents for successive improvements, and a subsequent inventor cannot use the property of a prior inventor without his consent. Obstruction from this cause is of rare occurrence; it may exist, but it is the interest of the owners of such property, and may safely be trusted in the majority of cases, to insure an arrangement beneficial to both parties. The remedy for any such case of real obstruction is obvious: apply to the owners of property in inventions the principle which has been so beneficially applied to the proprietors of land; let a person have the power of claiming a licence on payment of such a sum of money or on such terms as may be settled in case of difference by arbitration. The supposed sanctity of property in land has been invaded by the provisions of the Land Clauses Consolidation Act, and a clause introduced into every patent would provide an effectual remedy for the grievance in question, whether real or imaginary; the power to apply the remedy would eradicate the disease of the system.

Property in inventions is the only means yet suggested of rewarding the inventor; but the creation, duration, and enjoyment of that property may well become matter of municipal regulation, towards which the experience of many in this city cannot but fail, and I look forward with confidence to the result of this meeting as leading to a combined operation for attaining another great—if not a final—instalment of reform. It is essentially a working man's question, whatever relative position in society that man may occupy: it is one form of the contest between capital and labour—of that intellectual toil by which, as civilisation advances, man is to fulfil his mission to subdue and replenish the earth.

On an Electric Resistance Thermometer with Balancing Coil.

By C. W. Siemens.

The *Philosophical Magazine* for January last describes a method which the author had occasion to resort to for ascertaining the temperature of the interior of a mass of electric telegraph cable, suspected of spontaneous generation of heat. Coils of copper or platinum wire of known resistance were placed among the layers of cable (in coiling it), and leading wires were brought to an observatory, where the temperature of the cable could at any time be ascertained, in measuring the actual resistance by means of a Wheatstone Bridge arrangement and in comparing the result with the resistance of the same coil at standard temperature. The electrical resistance of a well-annealed platinum or copper wire increases in a very uniform ratio with increase of temperature, which enabled the author to determine the latter with a remarkable degree of accuracy. In endeavouring to simplify the arrangement he has succeeded in dispensing with the Bridge arrangement entirely, and, in fact, in reducing the observation to the reading of an ordinary mercury thermometer.

The apparatus consists of a differential galvanometer, and of a bath of water or oil, the temperature of which can be changed at will by opening one or the other of two cocks, the one bringing a supply of cold, and the other a supply of hot liquid, an overflow pipe being provided to prevent accumulation. A battery of from four to eight cells is also provided, besides a number of electric coils, consisting each of a certain length of thin insulated platinum wire, inclosed in a sealed metal tube. These coils having been carefully adjusted in the first instance, so as to offer equal resistance at one temperature, are connected to insulated copper leading wires of comparatively large sectional area (No. 16 B.W.G.), the ends of which are brought to the binding screws of the apparatus, to be inserted when required into a circuit including the battery and the galvanometer. These thermometer coils are deposited at the places where the temperature is to be observed, excepting one, which has to be reserved for comparison with the others. This last-mentioned coil is (through its leading wires) so connected as to form an electric circuit with the battery and the second coil of the differential galvanometer, and is immersed in the bath before mentioned. It is evident that if the temperature of the bath should be the same as that of the place where the thermometer coil under examination is deposited, the two electric currents proceeding from the battery will meet with equal resistance in the two circuits, and in passing the two spirals of the differential galvanometer in opposite directions will produce no visible effect upon the needle. If however the temperatures of thermometer and balancing coil should be unequal, the needle will be deflected by the preponderance of current in the cooler circuit, showing by the direction of its deflection whether cold or hot water should be added to the bath to establish equilibrium of currents. When this equilibrium is obtained the temperature of the bath is observed by means of an ordinary mercury thermometer, which temperature must be identical with the temperature at the distant place.

In dividing the thermometer coils into two portions, the apparatus is rendered applicable for observing wider ranges of temperature than can be directly obtained by the mercury thermometer. In this modified form it may be used for pyrometrical purposes.

In measuring the ordinary temperatures, the employment of equal and undivided coils is however not only the most simple arrangement, but has the advantage in its favour that the accuracy of the observation is not depending upon the rate of variation of resistance being uniform or even accurately determined. The heat produced in the coils by the electric current employed, affecting the two coils equally, is also completely compensated in using equal coils.

The late extensive conflagrations of hemp and jute have suggested to the author the idea that these instruments might be applied with advantage in detecting in this way spontaneous generation of heat, or in meteorological and other scientific observations where maximum and minimum thermometers are at present used.

On the Amount of the "Direct" Magnetic Effect of the Sun or Moon on Instruments on the Earth's Surface. By G. Johnstone Stoney, M.A., F.R.S.

In the *Philosophical Magazine*, for March 1858, Dr. Lloyd showed that the observed disturbances of the magnetic needle, depending on the hours of lunar and solar time, follow laws inconsistent with their being due to the direct magnetic attraction of the moon or sun. Hence it might be too hastily concluded, from the absence of observed effects following the proper laws, that these luminaries are not magnetic. The design of Mr. Stoney's communication was to show that, though as highly magnetised as the earth, their direct effects would be almost inappreciable.

The maximum moment which the moon could impress on the needle was first ascertained to be $2\frac{MM'}{D^3}$; where M and M′ are the magnetic moments of the moon and needle, and D the interval between their centres. It was then shown that we may substitute for the moon a globe a metre in diameter, of equally magnetic materials, and placed at such a distance as to subtend at the needle an angle equal to the greatest apparent diameter of the moon as seen from the surface of the earth. By applying to the problem in this form the numerical data elicited from the observations by the wonderful genius of Gauss in his memoir on the magnetism of the earth, the greatest direct disturbance which the moon, on the hypothesis of its being of as magnetic materials as the earth could produce, proved to be less than a tenth of a second of space on the declination needle, and less than the twenty-seventh on the dipping needle.

The observations with which these are to be compared have been made at several stations. The principal part of the observed lunar-diurnal variation consists of a term depending on twice the lunar hour angle, but there is also a small term containing the simple hour angle. This latter is that which, as Dr. Lloyd has shown, the direct action of the moon would effect, and General Sabine has determined its values at several stations scattered over the earth, in calculating the formulæ which best represent the observations. These values range (see the second vol. of the 'St. Helena Observations') from 0″·48 up to 2″·04. There is therefore no ground for presuming, from the minuteness of the coefficient, that the moon is not of as magnetic, or even much more magnetic, materials than the earth.

If the comparison with the earth be made mass for mass, instead of bulk for bulk, the above disturbances must be reduced in the ratio of the moon's density to that of the earth—that is, to about two-thirds of the values already given.

The same method of course applies equally to the sun, and whether his magnetic moment be conceived of as exceeding the earth's in proportion to his mass or to his volume, his maximum influence will be even less than that assigned above to the moon—for he never attains an apparent size as great as the maximum of the moon, and his density is only about half that of the moon.

ARCHITECTURAL ACCESSORIES OF MONUMENTAL SCULPTURE.*

By F. P. Cockerell.

The subject of the Architectural Accessories of Monumental Sculpture embraces so wide a field of research, and the line to be drawn between architectural accessories of sculpture and sculpturesque accessories of architecture, is in many instances so little defined, that to draw that line, and to sketch even superficially the leading features of the whole subject, would be matter for a volume. The narrowness of the limits of one evening's paper therefore constitutes in itself an apology for its incompleteness. All that can be done is to point to a few examples of the ancient schools, and, where the actual examples are wanting, to quote the authority of those who from the obscure hints of ancient historians have brought to light some of their principles of art. And if we compare with the few examples that remain the efforts of our modern schools—our own especially—we shall find that, obvious as these principles may appear, they have been sadly misunderstood, and too often utterly ignored by our artists. Perhaps the fault will be found to exist, not so much in the want of talent in these times, as in the spirit of utilitarianism, which, by insisting on the union of the artist and the tradesman in the same person, limits the artist to a single branch of art, and practically ignores that union of the three sisters in which alone true strength in art can be found.

Taking as an axiom that the object of a pedestal is to give dignity and importance to the group or figure which it supports, rather than to act as an architectural feature having a primary importance and interest of its own, our first desire in studying the subject is to find some fixed principle of design and rule of proportion to guide us in our combinations, such as are found to exist more or less positively in the *architecture* of every school. But if in the study of the present subject we turn to architecture, it seems at first sight to offer but little assistance; for when once we have established that the object of a pedestal is to give importance to the feature which it supports, the analogy in the application of the pedestal in the two arts seems to stop; for the precise and geometrical lines, and the spirit of line and rule, which constitute the essence of architecture, have nothing in common with the flow of line—the ever-varying, and as it were accidental forms of sculpture. Yet though it may not be possible to establish a direct and palpable parallel, or to apply the rules which govern the proportion and form of architectural pedestals to those of sculpture, still, the spirit which pervades one branch of art will be found to exist in the coeval works of the sister art, and a thorough acquaintance with the one cannot fail materially to assist us in our study of the other.

If we compare the few remaining examples of architectural and sculpturesque pedestals in the antique schools, there will be found a coincidence of principle in each school which will afford reasonable ground for adopting the architectural principle where examples of the other are wanting. We cannot enough regret the scarcity of authentic information on the subject of Greek pedestals, but such hints as are afforded by written descriptions, and the paintings upon vases, &c., should be regarded as the Sybilline books, and turned to account as best we may. It is no platitude to repeat that the Greek school is that from which all that is good in art is derived, more or less directly: it is that which beyond all others evinces the deepest thought and the most unerring principle, and which is least subject to that caprice which so frequently bewilders us and throws us off our scent in modern schools. Horace, in the often-quoted passage—

> "Exemplaria Græca
> Nocturnâ versate manu versate diurnâ,"

—says only what scores of writers and artists of all times have said or implied, if not with the same eloquence, with equal insistance.

Of the earliest style of art but little need be said, for though the monumental sculpture of the primitive schools of Greece (commonly called the Dædalian school) and of Egypt has great and peculiar qualities of its own, they are not such as will materially tend to illustrate the subject under consideration. It is not unworthy of remark, however, that the coincidence between the works of architecture and sculpture which we shall find in other schools exhibits itself also in the primitive works by the fewness of parts and the almost entire absence of those accessory features (as the pedestal) which are used in other schools to give scale and dignity to the leading features, and which the massiveness of the forms in the earlier schools seems to render less necessary. In Egyptian and Assyrian architecture the columns generally stand upon the ground, or, where they are raised upon a stylobate (as, for example, in the small temple at Philoe, commonly called the Bed of Pharaoh), the latter is of a height which gives it rather the importance of a leading feature than an accessory. The pedestal, properly so called, belongs altogether to a later and more complete style of art, and seems a natural step in the development as well of sculpturesque as of architectural composition. Even with the Greeks this feature is but rudimentarily treated in the earlier works, the stylobate of three steps (κρηπιδωμος) being the only approach to the idea of a pedestal until the introduction of the Ionic order. The Temple of the Giants at Agrigentum is the only example that I am aware of in which a base is applied to the Doric order. This and a greater number of steps in the stylobate seems to show a marked progress in the development of the principle involved in the use of the pedestal. As in the earlier architecture, so in the sculpture there is an entire absence of what may properly be called a pedestal. The sphinxes of the Sacred Way at Philoe have only a low square plinth, without architectural features of any kind. The colossi of the plain of Thebes, of the rock-cut temple of Ibsamboul, and many other examples, are treated in the same way. It should be observed however that in none of these examples is the secret of scale—namely, the subordination of parts and gradation of dimension—entirely omitted, though it is not applied by means of *architectural* accessories. The colossi are surrounded by smaller figures of nymphs and divinities, and the sphinxes and caryatid figures have hieroglyphics and incised ornaments upon the square plinths, which assist materially in giving importance to the principal object.

---

* Paper read at the Royal Institute of British Architects.

Of archaic Greek sculpture of monumental scale and character but very few examples exist. The sitting statues of the sacred way at Branchidoe, one of which is in the British Museum,—those cut in the rock at Palazzuolo, the ancient Acroe, in Sicily,—and a colossal lion, also cut in the rock, at Naxos, are some of the examples that I can quote. Pausanius mentions and gives descriptions of several which it would be foreign to our subject to refer to. These are very similar to the Egyptian sculpture, and are evidently derived from it: and they always exhibit the same absence of architectural accessories. There are many small statuettes of the Dædalian school, which were no doubt in many cases copies of colossal statues, and were used as votive offerings. Their pedestals (if any) have not been preserved. One of the volumes of sculpture published by the Dilettanti Society gives an example of a statuette of Minerva of this character, which has a pedestal. This is clearly a copy of a colossal statue, but it is highly probable that the pedestal may have been added to the original statue in later times, as in the case of the Apollo of Amycloe, and in other instances.

Having thus briefly noticed the earlier practice, and the absence of the feature which forms the substance matter of our consideration, we now come at once to the great times of art, when sculpture had reached its highest development, and when, as we may naturally suppose, the architectural accessories had reached the same pitch of perfection. It must be a matter of great regret that the sources of information upon this subject are so few, and that of the thousands of statues which adorned Athens and other great cities of Greece, none of the pedestals remain; so that the scanty descriptions given by Pausanius, Pliny, and other writers, and the conventional representations on vases, are the only sources of information. We may however derive some assistance in developing these scanty hints from the architectural pedestals of the period.

The school from which our modern practice is chiefly derived—if indeed it can be said to be derived from any school at all—is the Roman; a mere vulgarised imitation of the Greek, in which the substance is copied but faintly, and the spirit not at all. In looking through the examples of Greek architecture in which the pedestal occurs, one is struck first with the relative importance of the dimension of the column to that of the pedestal, in which such a marked difference from the Roman appears. In the Greek the pedestal never exceeds the height of the entablature, and is more generally about one-sixth of the height of the column, while in the Roman the proportion is usually not less than one-fourth. There are some examples of Roman architecture in which the Greek system has been adopted, as in the temples at Assisi and at Pola, and in the building called the Incantada, at Salonica. In the latter the pedestal is less than one-eighth of the height of the column; but these are exceptions to the Roman rule. The loftiness of the Roman street architecture appears to have rendered it necessary to elevate the order in public buildings and temples upon a higher pedestal, so as to give it a proper importance in relation to the surrounding houses. This necessity would hardly be felt in the same degree by the Greeks in their less crowded spaces. A second and not less important characteristic of the Greek pedestal is, that the width of the die is not much larger than the diameter of the column itself (namely, about one-sixth of its height); while in the Roman the width is equal to that of the base of the column. Thirdly, the Greek die commonly diminishes upwards, thus preserving in the pedestal the character which the entasis gives to the column, and as it were uniting the pedestal and column in one composition, and avoiding the apparent break in the line which is so observable in the Roman. Fourthly, the small dimension of the pedestal causes the cap and base mouldings to assume an importance which they have not in the Roman (without the actual size of the mouldings in reference to the column being increased), thereby imparting a rich and composite character, which, while adding to the mass, affords a valuable contrast by its horizontal lines to the vertical lines of the column.

In the Italian revival the Roman exaggeration of the pedestal was carried still further, until it became necessary to give such a development to the capping that it assumed the importance of a complete cornice, with bed mould, corona, and cymatium, instead of the simple moulding used by the Greeks. Thus the pedestal might almost be said to have ceased to be a part of the order incorporated with it and forming merely a base to it, and to have become a separate feature, with an importance entirely its own. The Taylor and Randolph Institution at Oxford affords an example of the low pedestal used by the Greeks. Those who are acquainted with that building will hardly fail to recognise the beauty of this feature.

Of sculpturesque pedestals of the Roman school a sufficient number of examples remain to trace the presence of the same defects which characterise the architectural pedestal. It will therefore not be an unwarrantable assumption to suppose that the same affinity between architecture and sculpture existed in the Greek, and the very scanty information which we have seems to confirm this supposition.

Thus much for the elementary principle of form and proportion *per se*, independently of the very important subject of the application of it to the various conditions of small, life-size, and colossal statues, which the small size of this paper will allow us to treat but superficially.

The next and most important principle which we have to consider is the giving of scale to the principal object by the introduction of ornamental and sculpturesque detail in the pedestal. The *principle* involved in this practice is, as we have observed, not forgotten in the earlier works of sculpture, but it is applied to the sculpture itself, and not to the pedestal, there being none to apply it to. The advantage of its application to the pedestal instead of to the principal object is obvious. There seems to be an irrationality in grouping together giants and pigmies in the same composition, as in the rock-cut temple of Ibsamboul, and many other examples, where a small figure stands by the legs of a large one. One accepts the expedient as one of necessity, and its grotesqueness is rendered less prominent by the conventional character of the whole work; but where the same thing occurs in later and more perfect works, as in the Toro Farnese at Naples, and the Nile God in the Vatican, one is at once struck with a sense of disproportion, and one is disposed to question whether a better means of giving scale might not have been used. There are not wanting those even who question the propriety of making the sons of Laocoon so much smaller than himself. When however the smaller figures are contained within the lines of an architectural form, and are subordinate to it, forming its enrichment only, they cease to come in competition with the statue, and only act as a foil. They are then no longer of the same nature with the statue. The fact of their forming a part of the architecture conventionalises them, and renders them inanimate things—stone or metal, while the statue represents a living creature. Quatremère de Quincy, in speaking of the Victory in the hand of the Olympian Jupiter at Elis, says, "There is no comparison to be established between the Victories placed in the hands of statues and the statues themselves. The figures of Victory in question, if one considers the usual conventions in this sort of composition, play the part only of images, not of living beings."

The greatest examples of the importance of the principle which we are now considering, namely, that of gradation, are the works of Phidias—the chryselephantine statues of Jupiter of Elis, of Minerva at Athens, and many others.* In these statues the smaller figures were not confined to the pedestal, but were introduced in every available space. The throne of the sitting figures, the shield of the Minerva, even her very sandals (on the edge), were covered with subjects; but these are mostly in basso-relievo, and in those parts where it is supposed that complete figures were introduced they formed part of some conventional object, as griffins subduing Greeks, which supported the arms of the throne. I find in Q. de Quincy an observation upon the importance which Phidias must have attached to the pedestal. He says, "We may conclude from a passage of the orator Themistecis, that the bassi-relievi of the pedestal occupied Phidias a long time. Although this artist says he had great ability in the art of representing in gold and ivory the figures of men and gods, nevertheless he required much time and leisure to finish these works. It is reported indeed that in the execution of Minerva he employed a considerable space of time in the works of the pedestal of the goddess." Pliny particularly dwells upon this fact. He says, "Among all nations which the fame of the Olympian Jupiter had reached, Phidias is looked upon, without doubt, as the most famous of artists. But to let those who have never seen his works know how deservedly he is esteemed, we will take this opportunity of adducing a few slight proofs of the genius which he displayed. In doing this we shall not appeal to the beauty of his Olympian Jupiter, nor yet to the vast proportions of his Athenian Minerva, 26 cubits in height, and composed of ivory and gold; but it is to the shield of this vast statue that we shall direct attention, upon the convex face of which he has chased a combat of the Amazons, whilst upon the concave side of it he has represented the battle between the gods and the giants. Upon the sandals, again, we see the wars of the Lapithæ and Centaurs,—so careful has he been to fill up every smallest part of his work with some proof or other of his artistic skill. To the story chased upon the pedestal of the statue the name of the Birth of Pandora has been given, and the figures of the assisting gods to be seen upon it are no fewer than twenty in number.

These statues are briefly described by Pausanias and Pliny, and they have been further illustrated by the learned and intelligent researches of M. Quatremère de Quincy. It will be sufficient to quote what he says about the pedestal of the Minerva of the Parthenon. He illustrates several others very fully, as the Jupiter of Elis, the Apollo at Amycloe, &c.; but we shall more readily realise that of the Minerva, knowing, as everyone does, the copy of that statue in the Studii at Naples, and that at Deepdene. In describing the statue he says,—"Her height, according to Pliny, was 26 brachia, or 37 feet French (about 40 feet English), without including the base, of which I shall speak in its place, and to which, as we shall see, it is not possible to give less than 8 or 10 feet; consequently, the whole must have been about 45 feet French, a height perfectly in accordance with that of the Naos, which, as we shall see, could not have been much more than 50 feet French, if we suppose the ceiling to have been horizontal." He says further on—"The height results necessarily from the two data which we possess—viz. the height of the temple, and that of the statue. Now we have shown that this height could not exceed 10 feet for the pedestal—a proportion perfectly in accordance with the method followed by the ancients in the relation of statues to their bases in the class of colossal sculpture in question," namely, that which is seen only from a limited distance. He again quotes Pliny, who says,—"On the base is engraved (*gravé*) what Phidias called the Birth of Pandora: one sees in it the birth (generation) of twenty divinities." He then goes on to show that, taking 6 of the 10 feet for the figures, and appropriating the other 4 feet to the capping and base, there must have been two rows of figures, as there would not be room for the whole number if they were of a size to occupy the whole height of 6 ft. "As to the division of the bas-reliefs into two rows, one over the other," says he, "I could, if necessary, quote a great number of examples in the antique." Having thus determined the height, it is evident that the width of the pedestal could not have been less than 18 feet, considering the expanse that must have been given to the lower part of the figure by the shield, the griffin, and the serpent.

If we restore in imagination these and other examples of which Pausanias and Pliny give descriptions, we shall find in them an illustration of what we constantly hear of, and never see—namely, perfect simplicity and unity, together with the greatest amount of richness and interest. In these the natural union of the arts of architecture and sculpture is most completely carried out, each preserving its own character, while, by the due relation of the one to the other, they combine in perfect harmony in one homogeneous composition. So soon as we turn from the Greek to subsequent schools, we find this quality of unity gradually disappearing; the architectural element dwindling away, and giving place to an exuberance of sculpture and ornament. The first step in this direction is the general substitution of alto for basso relievo in the Roman pedestals.* Of this there are abundant examples: for instance, a pedestal in the Studii at Naples, with figures of cities, which I believe formed the base of a statue of Titus; that in the Vatican Garden; and many other examples.

In the Gothic I am not aware of any examples of monumental sculpture not forming part of an architectural composition (except Calvaries); but in general we find that the due relation between architecture and sculpture is almost entirely lost sight of, as in the porches of cathedrals, &c., where it is difficult to say whether the sculpture is made for the architecture, or the architecture for the sculpture. Richness seems to be the object aimed at: the result obtained is profusion, not to say confusion. (I would not however be understood to disparage Gothic sculpture, which I have studied and drawn most reverentially, and in which I find inestimable beauties that belong entirely to itself. I am only speaking—as my subject requires—of the scientific relation of one art to the other.) In the revival, the Greek principle is recognised, though not so generally carried out. There are, no doubt, abundant instances of pedestals in which the relation of the architecture to the sculpture is well preserved; but in general, where richness and effect were sought, it was at the expense of the architectural element, while the monument, instead of being a statue or group, became a complete family, in which the accessory figures were scarcely subordinate to the principal, and the architectural part was merely something for them to sit upon. In the composition of tombs this prodigality is carried still further. One constantly finds little figures, mere dolls, each with its little niche, and each as complete in all its parts as the principal figure. No doubt the object sought, of giving importance to the principal figure, is obtained; but it is at the expense of the small figures, which appear insignificant, instead of preserving their own dignity while adding to that of the whole.

One of the most practically important points to consider in this subject is the difference of relative scale between the pedestal and its statue in the different conditions of small statues or statuettes, colossal statues, and life-size statues.† The latter case, again, is subject to a great variety of conditions, as the public statue in an open space, the memorial statue of less dimension in cathedral or hall, and the statue placed as an ornament in a gallery. Each of these conditions being so different from the other, and each again being subject to so many other conditions of its own, it would be impossible to attempt any rule which should be of general application. It is obvious that the smaller the statue the greater will be the necessary relative height of the pedestal, in order that it may in some degree be raised out of the way of harm, and placed fairly in view. It is not necessary to speak of small statuettes for ornamental purposes, as in such objects, which do not aspire to be ornamental, any caprice is more or less admissible. The subject of pedestals appropriate to a statue of a height of 3 or 4 feet, is one which comes more daily under our notice; but where the statue is placed upon the level of the eye, and the whole of the pedestal is below it, the detail is a matter of little importance, and the proportion is all we have to consider. In the paintings upon Greek vases there are two distinct classes of pedestals represented for small statues. Those of 3 or

---

* Minerva of Pellene; Minerva Polias; Minerva of Lemnos, said to be his best work; bronze Apollo in the Acropolis of Athens; Minerva of Platea, in marble and gilt wood; Venus Urania, in the temple of that name; the Mother of the Gods, in the Metroum of the Ceramic; Minerva Hygeia, in bronze on a gilt throne; Venus Celestis, at Elis; Minerva Erganè, in the citadel of Elis; and the Jupiter at Olympia.

* For proof of the use of basso by the Greeks see quotation from Pliny above.

† The expression, "life-size," must be taken to mean something more than life-size, this varying according to condition of situation.

4 feet high are generally placed upon a low square pedestal of about the same height as the statue. A subject frequently represented, and in which this occurs, is the Family of Priam taking refuge at the Altar at the Sack of Troy, and also Diomed carrying away a Statue from the Altar. It cannot be said that the proportion is a particularly agreeable one, and one must suppose that the comparatively large surface of the top of the pedestal was intended for the convenience of placing votive offerings, and that it was rather an altar than a pedestal. The other class of pedestal is the Stylé, a small square column of six or seven diameters high, and of about the height of the human figure (more or less). Sometimes it takes the form of a small Doric or Ionic column, and this again is sometimes placed upon a plinth or pedestal. This form of pedestal seems only to be applied to small images 1 foot or 18 inches high. This principle appears to be most suitable to its purpose, and is, indeed, that which in modern times is most frequently adopted for busts or small groups and statues. The form however which is generally adopted—namely, a shaft, without moulding or finish of any sort, and not diminishing, is not a very happy application of the principle. The simple hints given by the Greek vases are well worthy of attention.

Of the pedestals of colossal statues for exterior positions I have not been able to find any very reliable examples. What little information I have been able to gather, however, seems to show that it was low in proportion to the height of the statue. A coin of Athens, given in Millin ('Galerie Mythologique'), and also in Prof. Donaldson's recent learned work, 'Architectura Numismatica,' representing the Acropolis of Athens, shows the statue of Minerva Polias. Of course, in a conventional representation on so small a scale, it is impossible to depend upon the exactness of the proportion; but it is sufficient to show that the pedestal is not only low, but also very narrow in reference to the bulk of the figure. The restoration given in Quatremère de Quincy of the statue of Apollo at Amycloe, the pedestal of which was of the time of Phidias, or thereabouts, shows the same peculiarity. The remarkable coincidence between these examples and many examples in architecture of the smallness of the pedestal, seems to confirm the supposition that the pedestal of colossal statues was generally small in bulk compared to the base or lower part of the statue, which must almost have appeared to overhang the die of the pedestal. In the best works of the revival we find the same character. Many examples in Italy are familiar to every one: the colossal angel on the top of Castel St. Angelo; the colossi of David, by Michael Angelo, and that of Hercules and Caco; the statue of Marcus Aurelius at the Capitol, &c., are all examples of this in a greater or less degree. The principle is remarkably illustrated in the Perseus of Benvenuto Cellini; but the exuberance of ornament in the pedestal deprives it of the simplicity and unity which we find in the Greek. The importance which it gives to the statue however, must, I think, strike everyone. These however are but pigmies compared with the colossal statues of the ancients, the only things which approach to them in modern times being the statues of Bavaria, at Munich, and of St. Carlo Borromeo, at the Lago Maggiore. With the latter I am not acquainted. That of Bavaria affords, by contrast, an excellent illustration of the merit of the Greek principle. The height of the pedestal is rather more than one-third of the statue, and the width equal to the height. Thus the bulk is so considerable that, when near the monument, one sees nothing but the pedestal, which, at a distance—the statue having no preponderating relation to it—does not serve to give scale as an object of comparison. This defect is no doubt met by the contrast of the portico, consisting of a small Doric order, which surrounds three sides of the figure, and from most points of view forms a background to it. There are however necessarily points of view in which the eye does not embrace the monument and its background at once. In these aspects one cannot fail to be struck with the want of detail in the pedestal, which, having no features except the capping and base, and a moulded panel in the die, seems by its size to diminish rather than to give scale to the statue.

In the best examples of equestrian statues the pedestals are also generally small (relatively), though the proportion must naturally be influenced to a certain extent by the actual dimension of the statue. The pedestal of Marcus Aurelius, in the Capitol, is not so high as the horse's shoulder; those of Castor and Pollux, at the top of the steps of the Capitol, are scarcely higher: that of the equestrian statue of the Grand Duke, in the Piazza Granduca, at Florence, is still smaller. Many other instances might be quoted. But on the other hand, instances of the opposite system are not unfrequent. The statues of Bartolomeo Colleone, in the Campo St. Zani Polo, in Venice; that of Gatta Melata, in the front of the Santo at Padua, and of King Charles, at Charing-cross, all have pedestals of a very tall proportion. The necessity for reducing the bulk of the pedestals of equestrian statues seems to have been universally felt. This has been done, in most cases, by breaking the pedestal in its length, and making the ends semicircular on plan, by this means preserving such a length as shall be in accordance with the impression of motion inseparable from a horse. In the crowded streets of modern cities a statue placed upon a pedestal of so low a proportion as some of those quoted, would be lost, unless the statue itself were of colossal size. This difficulty has been admirably met in several of the compositions of Rauch, in which the pedestal itself, being small, is raised upon a plinth, which is in some cases again subdivided or elevated upon a stylobate of steps. Thus the barrenness of the long unbroken line so constantly adopted in our own statues is avoided. The moulded capping and base, and other enrichments, have a rich and full proportion in reference to the die of the pedestal, without the exaggeration of actual size which becomes necessary in the large pedestals so commonly in use. Thus the outline of the pedestal, rich in itself, without crudely salient features, combines harmoniously with the statue, and with it engages the eye; so that the plinth or podium below, being of the most simple and severe form, may be raised or lowered without materially affecting the composition of the principal object. We must suppose that it is this difficulty of the unavoidable prominence of the capping in large pedestals which has offuscated the genius of some of our own sculptors, and driven them to the disastrous expedient of dispensing with all moulding in their pedestals,* and placing their statues upon the chopping-blocks that offend our eyes in too many of our public places. It is not so easy to find a reason for the prodigious bulk of some of them, which are large enough to admit of a house being built upon them over the statue's head. I have not been able to discover the authority for the rapid diminution of the block sometimes adopted, which gives to the pedestal the character of a truncated pyramid: neither is the advantage of it at once patent. Much might be said upon the subject of London pedestals, but such has been the neglect of this accessory of monumental art that there would be but little room for favourable criticism. Our sculptors can scarcely be aware how much of the undiscriminating, though deserved abuse, levelled at many recent public monuments, is due to the entire absence of design and proportion in the pedestals. We must suppose that they do not attach the same importance to the subject as architects do. If they did, some knowledge of architectural detail, and a more careful attention to the examples exhibited by the revived schools, and the more recent works of some other countries (Prussia in particular), would save our public monuments from many a deserved reproach. In these days of hero-worship, when so many statues are springing up, the subject is one of daily increasing importance, and calls for a unity between the sister branches of architecture and sculpture, through their professors, to avert the torrents of abuse which, rightly or wrongly, are poured upon each new monument.

◆

MR. R. H. BOW'S INSTANTANEOUS LEVEL AND GRADIENT INDICATOR.

This simple and ingenious little instrument is an improved variety of those described before the Scottish Society of Arts, and of which engravings have been given in this Journal (vol. xxii. p. 108, and vol. xxiii. p. 80). It is designed to furnish a ready means of approximating to either the true level or any required gradient, and seems calculated to be very serviceable in the laying out of roads, especially where the ground is hilly.

Where great accuracy is required, as in fixing the gradient for a railway, recourse must be had to the usual optical level, with its stand and levelling screws. But for running the contour line round a hill for a common road on the level or at a given gradient, those means will generally be thought the best which are

---

* There is a moulding which, though unknown to architects, is in frequent use as a base moulding in these monuments. It resembles a reversed echinus, and is, as I am credibly informed, called a thumb-moulding. The name at least has the merit of being in unity with the principle of design employed in the rest of the pedestal.

the most expeditious and convenient; and here we think Mr. Bow's invention would prove very useful.

The instrument is as compact and portable as a carpenter's level, which it resembles in presenting the external appearance of a rectangular wooden box, with a slit in the top through which the bubble is visible. It may therefore be used if required like a common workman's level. But for field work it is of course intended to be looked through, and cross-hairs are fixed, for giving the line of view on a level, or at gradients ranging from 1 in 60 to 1 in 10. Two eye-holes are given, one for rising and the other for falling gradients.

It is evident that this level is best placed on a rod or stand when used, but there is no need for the three-legged stand and the levelling screws which are essential to a "dumpy." A narrow strip of mirror is so placed inside as to show the observer when the bubble is in the right position, without his having to withdraw his gaze from the field of view. The level tube is very delicate for its size, as it is filled with chloroform. One end of the instrument should be gently raised and lowered, so that the bubble may be seen moving slowly backwards and forwards in the mirror, and a mean should be taken between the two readings on the staff. If the level is supported on a rod, it would be convenient to have the height of the rod marked on the staff. A very convenient way of using the instrument would be with two "boning sticks"—one to rest it upon and the other to sight on. The maker gives his name as Alexander Reid, optician, South-bridge, Edinburgh.

REPORT OF COMMITTEE ON DECAY OF THE STONE OF THE NEW PALACE AT WESTMINSTER.

The Committee appointed to inquire into the decay of the stone at the New Palace at Westminster have made their report to the First Commissioner of Works, as follows:—

Report.

Sir,—We the undersigned, being the Committee appointed to "inquire into the decay of the stone of the New Palace of Westminster, and into the best means of preserving the stone from further injury," have the honour to submit to you the following report, in which we have adopted as the objects of our inquiry the several points referred to by your letter of appointment and instruction, viz.—

I. The extent and position of the decay.

II. The causes to which it is attributable, taking into consideration the composition of the stone, and the influence exerted upon it by moisture, and by the acids diffused in the London atmosphere.

III. The best means of preserving the stone from further injury.

IV. The qualities of the stones to be recommended for future use in public buildings to be erected in London.

1. In proceeding with the important inquiry thus intrusted to this committee, we beg to state that we first made a careful inspection of the whole of the buildings; and that after this inspection we proceeded to obtain such evidence as appeared to us best calculated to facilitate the inquiry intrusted to us, by examining a considerable number of witnesses who had been connected with the building from the commencement, or who had been concerned in the various processes which had been actually tried for arresting the decay which had occurred; and also another class of witnesses who had suggested various theoretical remedies for the same purpose.

2. We delegated to a sub-committee, specially appointed, an examination and inquiry into the condition of other buildings erected in the metropolis in which magnesian limestone had been used; and we particularly called the attention of the scientific chemists who had been appointed on the committee to several points peculiarly within the limits of their acquaintance with chemical subjects.

3. We also considered it expedient to invite by advertisement the attention of chemists and others to the subject submitted to the committee; requesting that any plan or suggestion for the prevention of decay or for arresting its progress might be brought under our notice.

4. Having thus premised the course the committee thought it expedient and desirable to take, we now proceed to report seriatim on the subjects brought under our notice by your instructions, and in the order adopted therein.

The Extent and Position of the Decay.

5. It is extremely difficult to give any very exact account either of the extent or actual position of the decay. It seems from the evidence that it first began to make its appearance in the portions of the Palace of Westminster executed at the commencement of the building, about seven years after their execution; and yet, in some of the most recently executed portions—viz. those towards Old Palace-yard, facing Henry the Seventh's Chapel, the decay appears to be as obvious as in any other part of the building.

6. In the earlier works—viz. those towards the Thames, the decay is most apparent in the lower portion of the building; and in this portion the decay is confined to what may be called "zones," or general levels; which would seem to suggest that it depends as much upon position in the building as upon the use of particular beds of stone from the quarries employed.

7. The same remark applies to the part of the palace fronting the approaches to Westminster-bridge, where the decay of the lower portion is considerable; but in the newest work, facing Henry the Seventh's Chapel, the decay occurs in positions which are more varied, and under circumstances which it is exceedingly difficult to appreciate.

8. We have examined with much care the upper portions of the building, and we cannot perceive that the decay has made any important inroad upon those much more exposed portions where decay might more reasonably have been expected. The decay however occurs again to a considerable extent in the inner courts, which are sheltered in a great measure from external influences; and perhaps the very worst specimen we have noticed is to be found in the small archway leading to the reporters' gallery, near the entrance to Westminster Hall,—a part of the work as much sheltered as in the nature and circumstances of a public building it could well be.

9. The general result of our observations, confirmed by the evidence, would seem to suggest that the stone used in the Palace of Westminster is much more likely to decay in damp and sheltered situations than where it is exposed to the full action of atmospheric influences. In the east and north fronts before adverted to, the worst symptoms occur in the ashlar between the upper and lower mouldings of the plinth, and under the first cornice, where the exposure is inconsiderable; but the dampness, arising from the drip of the mouldings and the action of capillary attraction in cases where projections hold the moisture, appears to exercise an important influence on the condition of the stone itself.

10. It does not appear to us that the decay is attributable, as is commonly supposed, to the stones in the building not being placed upon what is technically called their natural bed, or in the same relative position as they occupied in the quarry: thus, stones which are found horizontally in the quarry appear to have been often placed perpendicularly in the building, and used for purposes of the most delicate decoration without any injurious result. As an instance of this fact, we may point out the elaborately carved shields of arms under the range of the first-floor windows: the stones used for these shields, though universally placed perpendicularly to their natural position in the quarry, present, so far as we are aware, few (if any) symptoms of decay.

11. The extent to which the decay on the whole surface has proceeded it is not very easy to estimate. At the present moment the actual decay is doubtless considerable for a building so recently erected; but the change of colour in the stone itself, and the "fretting out of the surface," which are suggested as the first symptoms, lead us to apprehend that there may exist much more mischief than at present is actually apparent.

12. One of the witnesses examined however, and whose judgment as a practical man is of considerable value, is of opinion that the decay, after proceeding to some depth in the stone, stops of itself; that an induration of the surface takes place, and that no further decay ensues. The committee would willingly accept this opinion, if they considered it well founded; but they cannot conceive that it is true to any considerable extent, notwithstanding there may certainly be some few indications which lead to the belief that in some cases it may be correct.

13. At present the decay appears for the most part on the plain surfaces, whilst the finer and more elaborately-wrought portions of the building, unless under projections, are not seriously affected. And however disappointing and disfiguring these effects may be, especially in a building so recently erected, the committee are of opinion that at present the decay does not affect the stability of the structure.

The Causes to which the Decay is attributable.

14. This part of the inquiry naturally leads to a reference to the evidence which has been obtained by the committee on the subject of the stone itself. The result of this evidence may be thus briefly stated. The stone recommended by the commissioners for this building was that from the quarries of Bolsover Moor and its neighbourhood; and this stone was actually contracted for in the first instance. Before the work began, however, it was found that blocks of sufficient size could not be procured from those quarries; and in consequence, one of the commissioners was appointed to proceed to the spot, to ascertain whether other quarries might not be discovered furnishing stone in beds of greater thickness and of larger dimensions. These conditions were found in the quarries at Anston, and the stone of greater thickness procured from these quarries has been used not only in this building, but in all the other buildings constructed of magnesian limestone in the metropolis, after the quarries of Bolsover Moor had been abandoned for the reason above stated.

15. The recommendation of the Bolsover stone in the report of the commissioners was founded on its similarity to that used in the Norman portion of Southwell Minster, which were stated in the report to be in a high state of preservation. Evidence has since been adduced, in a letter from Mr. Scott, which renders it probable that the stone of this

minster was really obtained from the ancient quarries of Mansfield Woodhouse. The latter quarries were reopened, and a considerable quantity of stone from them (exceeding 20,000 cubic feet) was made use of in the Palace at Westminster; but in their turn they were relinquished, from dissatisfaction as to the size of the blocks, though we have it on evidence, confirmed by our own observation, that the stone used from these quarries has stood remarkably well.

16. The evidence brought before your committee on the subject of the stone obtained from the Anston quarries is very conflicting; the contractor and his principal foreman stating that the stone was, with slight exceptions, extraordinarily good; while other witnesses maintain that even in the quarries themselves there are stones in a state of actual decomposition; and one very important witness, a foreman employed at the Palace at Westminster, asserts he knew that certain beds in some of the quarries were liable to decay, and that he abandoned them in consequence. With reference to the selection of stone the committee venture to remark that it is much to be regretted that the offer made by one of the commissioners, particularly well acquainted with the selection and working of stone, to examine that used in the Palace at Westminster for the moderate salary of £150 per annum, was not accepted, owing to some difficulty in regard to the party who was to be held responsible for this unimportant amount; and that the matter was left to persons who admit that they had little or no prior experience of this description of stone, though they evidently entertained suspicions of the durability of some of it which they were employing.

17. With reference to the very natural and important question of the actual causes of the decay of this stone when exposed to the London atmosphere, the committee take the liberty of referring to the report of the chemists, who were members of the committee, to whom this question was specially referred. (See page 339.)

The best Means of Preserving the Stone from further Injury.

18. This part of the inquiry referred to the committee naturally divides itself into two questions—namely, as to the steps that have hitherto been taken, whether experimentally or otherwise; and as to those that are to be recommended for adoption hereafter. With regard to the first question, we have ourselves examined with care the result of what has been done at the Palace itself, either experimentally on the river front, or, as in the inner courts, by actual coatings or washings over large surfaces. With regard to the second question, our inquiries have been earnest and elaborate, and we have examined many witnesses and given much time to the considerations of the various propositions obtained by advertisement or otherwise. As will be seen in a subsequent part of the report, we finally referred this question to the further consideration of the professional chemists who were on the committee.

19. On the first question the committee are decidedly of opinion that it is not necessary or desirable to proceed with any general coating, painting, oiling, or washing of the whole building. It is quite obvious, in their judgment, that a very large proportion of the stone does not require any such application; but that what is wanted is some efficient process which should be applied to the surface of any stone that begins to show symptoms of decay, with a view to arrest its progress. The committee believe that the persons to whom the care of the building is entrusted ought to watch it, and note, in the very earliest stages, wherever decay is perceptible, by efflorescence, change of colour, crumbling, or slight decomposition.

20. In cases where the decay is important, and evidently occasioned by the fall of rain on an upper projecting or exposed surface, protection should be afforded by a covering of sheet zinc or lead; and if hereafter any composition should fortunately be discovered by which the decaying stone could be at once covered or coated, and the injurious influences of the atmosphere prevented from further acting upon it, the difficulty would be solved. In some extreme cases the decayed stone might be cut out, and replaced by a new one. With regard to the processes which have actually been applied, whether experimentally or extensively, your committee are decidedly of opinion that the discovery of a proper mode of treating stones in a state of decay has not yet been made; and there is no evidence whatever on the building itself to induce them to believe that the decay, where decay has arisen, has been arrested, or that permanently the decay has been prevented, by any of the processes yet applied.

21. With reference to the second question we found ourselves unable, after much labour, to come to any definite conclusion; and we finally requested the chemists in the committee to examine and report upon it; but those gentlemen state, as appears by their report appended hereto, that the nature of the inquiry is so extensive, and that time is so important an element in the solution, that they are unable to give any opinion upon the subject. They further state that they spent five whole days in the examination of only one suggested remedy; but they are unable notwithstanding to give any opinion on even that one suggestion. They allude to secret processes, regarding which they say they can offer no opinion; but they express a doubt of the applicability of any suggestion which would demand the veil of secrecy for protection. Concurring in this view, it may be further noted that even if such application were found successful in sample or experiment, no security would be afforded for a corresponding success in any subsequent large operations. They recommend that a series of experiments should be conducted, under chemical supervision, for a considerable period of time; and the committee are most reluctantly compelled to coincide with them, and to urge upon the government the adoption of such a course.

The Qualities of the Stones to be recommended for Public Buildings to be erected in London.

22. On this head of the inquiry the committee have been unable, in the time allotted to them, to go into any very extensive examination. It is obvious however that although some varieties of magnesian limestone are an excellent and durable material when not exposed to the deleterious influences of the London atmosphere; yet that in London it is subject to causes of decay, which render it an undesirable and unsafe material for the construction of public buildings.

23. It is equally obvious that Portland stone, well selected, has been used in buildings in London from the date of St. Paul's downwards, under circumstances of great exposure, and with most successful results. Portland stone is a material to be obtained in any quantity, and in blocks of any size, beautiful in colour and texture, reasonable in price, not by any means so hard as the Anston stone, and yet with a power of resisting the influences of the London atmosphere that leaves but little to be desired. It must be remarked however that Portland stone should be carefully selected; an operation which would be most satisfactorily effected by an agent at the quarries.

24. On this subject the commissioners could of course bring much personal experience to bear; but after the valuable explanation of the principles upon which the decay of stone depends in populous places, as given by the chemists in their report before referred to, the committee refrain from repeating those conclusions, in which however they entirely concur.

25. During the inquiries of the committee, one of their number, Mr. Burnell, who is well acquainted with architectural and engineering works in France, undertook, at his own expense, a journey to Paris, to inquire into the practice of the French architects engaged in the government works in that metropolis. There the stone used, the "calcaire grossier," though a carbonate of lime of tertiary age, and therefore of very different mineral composition from our magnesian limestone of the much older Permian age, seems to suffer also from decay in a comparatively pure atmosphere, and where wood is chiefly used as fuel.

26. From the evidence of Mr. Burnell it does not appear that the French architects or chemists have been more successful than ourselves, either in the use of materials not subject to atmospheric influences, or in the application of processes for arresting decay when it has once begun. The opinions of the most scientific chemists and architects in France on this subject have however in this way been obtained; and it is extremely probable that the inquiries undertaken by them, simultaneously with those undertaken in this country, may hereafter lead to some successful results.

27. The committee have to thank the government for the facilities given to Mr. Burnell in this important part of the inquiry, by providing him with an introduction which obtained for him the active assistance of her Majesty's ambassador at the court of the Tuileries.

28. The committee delegated, as before stated, to a sub-committee the duty of examining the various buildings in London in which magnesian limestone from the Anston quarries has been introduced in the external architecture. The report of this sub-committee forms part of the Appendix; and we beg to refer to that report as confirmatory of our opinion of the uncertain character of magnesian limestone, and the risk attending the use of it in London.

29. In conclusion, the committee venture to recommend that the architect of the Palace of Westminster, assisted by scientific chemists, should examine and record the actual state of the stonework of the building at the present moment; that experiments should be made by their direction, under various conditions of height, exposure, and aspect, with such preservative materials and agents as the chemists may suggest from time to time; and that researches should be continued into the effects of the various alkaline silicates, the phosphates, and other substances which have been brought under the notice of the committee, or suggested in Germany, France, or elsewhere; and that where decay arises from damp, means should be taken to protect the stone, as has been before suggested; that any stone extensively decayed should be removed and replaced; but that in particular the earliest symptoms of decay should be carefully watched, and examined, with the view to some immediate remedy. The committee believe that a very large portion of the stone in the Palace of Westminster is of a very durable nature; and they entertain a confident expectation that a remedy will soon be found to arrest or control the decay when it has unfortunately began to appear.

William Tite.
Rod. I. Murchison.
Sidney Smirke.
George Gilbert Scott.
George Godwin.
M. Digby Wyatt.
A. W. Hofmann.

E. Frankland.
F. A. Abel.
James Tennant.
George R. Burnell.
Thomas Hawksley.
Charles H. Smith.
Edward M. Barry.

Alfred Bonham-Carter, *Secretary.*

Report of Sub-Committee of Chemists, referred to in the foregoing.

Sir,—We have the honour to inform you that we have complied with the wishes of the committee, by examining into the several proposals which have been laid before them for the preservation of the stone of the New Houses of Parliament; and that we have arrived at the following conclusions:—

1. Amongst the processes proposed, varying in principle and value to a very considerable extent, there is not one which we at present feel justified in proposing that the committee should definitely recommend as a preservative, either for general or local application.

2. A minute examination into one class of processes, submitted to the committee at an early period, has convinced us that, surrounded with great difficulties as the subject appeared at the outset, the obstacles eventually met with in an effective experimental inquiry are of a far more formidable character than could have been anticipated. Having devoted five days exclusively to the practical study of one of those processes (Ransome's), and having been unable, in that period, to elaborate even this single process sufficiently to warrant us in expressing a definite opinion upon its merits, it is obvious that anything like an elaborate examination of the numerous proposals which have only just now been submitted to us would require the expenditure of a far greater amount of time than the committee could place at our disposal.

3. Whilst regretting that it is not in our power to lay before the committee a positive recommendation of any particular process, we beg to submit the following observations:—

An examination into the nature of the several processes proposed leads to their classification under two heads—

(*a*) Processes which are likely to afford permanent protection to the stone.

(*b*) Processes which are only calculated to afford protection of a temporary character.

In both of these classes there are proposals which may be at once excluded from further consideration, on account either of their inapplicability to stones when placed in a building, or of the obvious misapprehension on the part of the proposers of the problem to be solved.

A proposal to protect stones by immersion in a boiling mixture of pitch, or resin, and oil, may be quoted in illustration of the processes which are only applicable to stones previous to their having become integral parts of any structure. Again, the suggestion to cover the building with a coating of a mixture of silica with sulphur, applied in a semifluid condition, would involve almost insurmountable difficulties in its practical application; not to speak of the inflammability of the sulphur, which is only slightly diminished by the presence of the silica; or the uncertainty of the temporary character of the protection which, under the most favourable circumstances, could be afforded by this material.

Several of the suggestions are based upon notions so obviously erroneous, such as coating the building with sulphate of lead, and procuring an alleged galvanic protection by establishing connections of this coating with plates of zinc; or, of ridding the building of the principle of decay by fermentation—that no object whatever could be gained by entering more fully into the merits of these proposals.

Of the processes which are intended to afford permanent protection to the stone, and the use of which is not precluded by the conditions of the case, there are several which claim a careful investigation. These processes may be classed under the following heads:—

1. Application of silicates of the alkalies, in various states of concentration.
2. Application of silicates, in conjunction with various saline compounds, intended to produce double decomposition.
3. Application of hydrofluoric or hydrofluosilicic acid, or their saline compounds.
4. Application of phosphoric acid, and acid phosphates.
5. Application of solutions of the alkaline earths, or their bicarbonates, in water.

All these processes are more or less based upon chemical considerations, which are supported by analogy, and which, in the case of the two first-named classes, have received considerable experimental confirmation. The experiments which are now in progress with several of the processes included in the two first sub-divisions, will, we believe, in the course of a few years, furnish ample data for correct conclusions regarding their applicability. In the meantime it might be advisable to apply to portions of the New Houses of Parliament actually undergoing decay, certain processes selected as representatives of the remaining classes above enumerated, in order that their merits might be submitted to the only conclusive tests—those of actual application, and protracted exposure to the corrosive influence of a London atmosphere.

The second division of processes—namely, those which are only calculated to afford protection of a temporary character, are, from their very nature, of minor importance for the purposes of the committee's inquiry; nevertheless, as the claims to permanence of none of the processes of the first division have as yet been substantiated by the test of time, we would recommend that, in addition to the experiments already made in this direction, further trials be instituted of some of the more promising materials of this particular description. This recommendation is based upon the consideration that substances included under the appellation of organic differ essentially in their powers of resisting the destructive action of the atmosphere. Whoever is acquainted with the nature of organic substances cannot fail to appreciate the different degrees of stability under atmospheric influence exhibited by gluten, gelatine, or starch (which we find enumerated among the proposed protective agents), and by bees'-wax and paraffine—not to speak of many of the fossil gums—which exhibit a degree of permanence approaching that of mineral substances.

The materials which we would recommend for selection to be tried in comparison with linseed oil, are paraffine, bees'-wax, and some of the more permanent gums and resins, applied in the form of solutions in volatile solvents.

We should not omit to remark that some of the witnesses and others who have addressed the committee speak of secret processes. We cannot, of course, offer any opinion regarding such proposals; but we should doubt the applicability of any suggestion which would demand the veil of secrecy for protection.

Finally, we beg to state as the result of the experience which we have been enabled to acquire during the prosecution of our investigations on this subject, that a definite solution of the question at issue can only be arrived at after the lapse of a considerable period; since the relative merits of the processes which we recommend for trial can be established only by the test of time.

A. W. Hofmann.
E. Frankland.
F. A. Abel.

Report of Sub-Committee on the Nature and Causes of Decay of Building Stones.

Sir,—Having been requested to submit to the committee our opinion on the nature and causes of the decay of building stones generally, and of the stone employed in the construction of the New Houses of Parliament in particular, we now have the honour to submit the following observations:—

Building stones in general may be divided into two classes,—1. Those which consist of materials not easily acted upon by acids; 2. Those composed of materials which are partially or entirely acted upon by acids with facility.

As an illustration of the first class, granite porphyries and serpentines, may be quoted; whilst to the second belong limestones, dolomites, and certain sandstones containing carbonate of lime as cementing material.

The stone used in the New Houses of Parliament belongs to the second class of building materials; consisting as it does almost entirely of the carbonates of lime and magnesia. The following analyses of several varieties of dolomite by Prof. Daniell and Messrs. T. Ransome and B. Cooper, are quoted in illustration of the general composition of the stone in question. (See table, p. 340.)

Regarded from a purely chemical point of view, the difference in the resisting power to corrosive agents of different stones would appear at first sight to depend entirely upon their chemical composition; but even a moderate acquaintance with the properties of the components of such building stones demonstrates that there are other conditions at least equally instrumental in determining the degree of permanence of different stones.

It is a well-established fact that *the same* chemical substance exhibits in different conditions a great variation in its behaviour with chemical agents. Numerous examples might be quoted in illustration of this. Thus, marble and chalk are chemically identical; but owing to the difference in their physical structure, the one being crystalline and the other amorphous, the former is much less readily acted upon by acids than the latter. Again, artificial peroxide of iron is readily soluble in acids; peroxide of iron, in the form of hæmatite, is attacked with difficulty by acids; and the same oxide, after exposure to a powerful heat, is almost entirely insoluble in acids. The influence of aggregation in these instances, and in numerous others which might be quoted, is obvious and generally admitted by chemists, however different and imperfect may be their views regarding the connection between physical condition and chemical effect.

The observations just made regarding the behaviour of substances such as enter into the composition of building stones, cannot but apply with equal force to the aggregates of such components to the building stones themselves.

The atmospheric influences to which building stones are subject are many of them essentially chemical actions, involving processes analogous to, or identical with, those performed in the laboratory; although from the extreme dilution of the chemical agents, as existing in the atmosphere, they must necessarily be of a very gradual character.

There are few instances in which the influence of the state of aggregation upon the permanence of a building stone is more apparent than in that of the dolomitic limestone, used in the construction of the new Houses of Parliament. Here, in one and the same block of stone of comparatively small dimensions, we find certain portions of the surface powerfully disintegrated, while others appear in a perfectly sound condition. Chemical analysis has hitherto failed to establish any important difference in the composition of sound portions of such stones and those

	Bolsover Moor.		North Anston.		Woodhouse.	Steetley.
	Daniell.	Ransome and Cooper.	Ransome and Cooper.	Ransome and Cooper. Stone Ends.	Ransome and Cooper.	Ransome and Cooper.
Carbonate of lime	51·1	52·07	54·80	55·37	52·80	53·95
Carbonate of magnesia	40·2	40·60	42·07	41·71	44·31	43·78
Sulphate of lime	...	...	...	...	...	trace
Paotoxide of iron	...	0·89	0·49	0·73	0·63	0·64
Oxide of iron and alumina	1·8	—	—	—	—	—
Peroxide of iron	...	0·83	0·24	—	—	—
Protoxide of manganese	...	trace	trace	1·68	Carbonate. 1·84	—
Silica	3·6	3·64	0·56	0·92	0·47	0·44
Water...	3·3	0·48	0·51	0·45	0·23	0·12

	Roach Abbey.	Huddlestone.	Park Moor.	Lindley's Bolsover Quarry, Woodhouse, near Mansfield.
	Daniell.	Daniell.	Daniell.	Ransome and Cooper.
Carbonate of lime	57·5	54·19	55·7	54·05
Carbonate of magnesia	39·4	41·37	41·6	38·58
Protoxide of iron	...	...	...	0·74
Peroxide of iron	...	...	...	0·62
Oxide of iron and alumina	0·7	0·30	0·4	—
Carbonate of manganese	...	...	...	2·43
Silica	0·8	2·53	—	1·30
Water	1·6	1·61	2·3	0·46

parts which are subject to decay: it is therefore legitimate to attribute the unequal permanence of the stone, under atmospheric influences, to such structural differences as may be comprehended under the term—state of aggregation.

Before proceeding to an examination of the particular character of the decay observed in the stones of the new Houses of Parliament, it may perhaps be desirable to glance at the nature of the changes to which building stones generally are subject under atmospheric influences. Under normal conditions these changes must be ascribed to the action of the oxygen, carbonic acid, nitric acid, and water, in the atmosphere. In the air of towns however there are certain other constituents, such as several acids of sulphur, and occasionally hydrochloric acid, which cannot fail to exert an additional disintegrating influence upon building stones.

The action of oxygen must be of comparatively a subordinate character; its effects being confined to constituents which occur but rarely, and generally in limited proportions, in building stones; such as the sulphides of iron, and the protoxides of iron and manganese; these compounds, being very prone to oxidation, would tend to disintegrate the stones by the absorption of oxygen. Of far greater importance are the effects of carbonic acid and water. Carbonic acid in the presence of water is a powerful solvent: it not only corrodes the calcareous and magnesian carbonates (more or less powerfully according to their state of aggregation), whether they form the principal constituent of the stone, or are only present as cementing materials; but is capable even of attacking and gradually decomposing the hardest and most indestructible rocks.

In the case of the calcareous and magnesian constituents of stones, carbonic acid acts by transforming the insoluble earthy carbonates into soluble bi-carbonates, which are thus removed from the substance of the stone; whilst its influence on silicious rocks consists in the elimination of the alkaline bases in the form of carbonates, and the separation of the silica in a more or less friable condition. The weathering of granites, and their gradual transformation into the several varieties of porcelain clay, afford an interesting illustration of the latter kind of action. In the changes just mentioned the carbonic acid and water are equally concerned; the water serving not only as a vehicle for the introduction of the carbonic acid into the pores of the stone, but also as a solvent for the products of its action. There are changes however to which building stones are subject in which water is the sole agent, and which are more of a mechanical than a chemical character. The expansion which water undergoes in freezing, and the irresistible force which it then exerts, are well known; it is obvious that water freezing within the pores of a stone must exercise a disintegrating action not less powerful than those above referred to.

Recent researches have demonstrated that nitric acid is a frequent and perhaps even a normal constituent of the atmosphere; and as such must undoubtedly assist in the destruction of magnesian and calcareous stones; but the proportions in which this acid has been found are so minute that it need not be dwelt upon as an important destructive agent. This remark however does not apply to the acids referred to above as existing in the atmosphere of towns. The quantity of sulphur acids in the air of towns where a considerable amount of coal is consumed is quite appreciable. According to the determinations of Dr. Angus Smith, the air of Manchester contains an average proportion corresponding to 1 part of sulphuric acid in every 100,000 parts of air, which in the centre of the town rises to 25 parts in 100,000. No numerical data exist with regard to the proportion of sulphur acids in the London atmosphere; but it can scarcely be doubted that in the neighbourhood of the new Houses of Parliament they are present to an extent equal to the average amount found in the Manchester air: they must therefore be regarded as among the more important agents destructive to stone which are present in the London atmosphere.

A few observations remain to be offered regarding the particular nature of the decay manifesting itself in some of the stone of the new Houses of Parliament. It has already been pointed out that, so far as our experience goes, we are inclined to attribute the local character of the decay to structural differences obtaining in different parts of the stone. The general structure and the composition of the stone in the new Houses of Parliament render it moreover amenable to all the sources of disintegration which we have above enumerated, with the exception perhaps of oxygen, which can scarcely produce any appreciable alteration in dolomite. Thus, the chemical action of carbonic and sulphuric acids in combination with water will gradually dissolve and remove the carbonates of lime and magnesia, whilst the porous nature of the stone renders it liable to the mechanical effects of water under the influence of frost. The presence of sulphuric acid in the air of towns appears in the case of magnesian limestone to bring into play another process of destruction. This acid not only corrodes and renders soluble, as we have pointed out, the earthy carbonates (in which respect it resembles carbonic acid in its effects), but, forming with magnesia a readily crystallisable salt, the well-known sulphate of magnesia, remarkable for the large proportion of water of crystallisation which it fixes, it gives rise in addition to a mechanical destruction of the stone precisely similar to that produced by freezing water. The powerful mechanical effects resulting from the solidification of water induced by crystallisation are well known; although it would appear that they have not hitherto been sufficiently appreciated as auxiliaries in the process of disinintegration of stone. The analogy between the solidification of water by freezing and by crystallisation is perfectly obvious; and a French chemist has suggested, as a means of recognising stones liable to disintegration by frost, to immerse them in a solution of sulphate of soda, and to note the subsequent effects of its crystallisation within the stone.

We have ourselves recently had occasion to observe some phenomena which go far to elucidate these destructive effects of crystallisation. The exfoliations exhibited by many of the fictile vases deposited in the British Museum were found to be due to the formation and crystallisation within the substance of the vessels of nitrate of lime. Again, in experiments on the preservation of fabrics by impregnation with saline substances, it was found that the crystallisation of sulphate of magnesia within the material produced a disintegrating effect upon the fibres, sufficient greatly to weaken the material.

In conclusion, we would remark that the effect attributed to the crystallisation of the sulphate of magnesia in assisting the decay of dolomitic stones, and more particularly of those used in the construction of the new Houses of Parliament, is borne out by the existence of a marked efflorescence of sulphate of magnesia upon those portions of the stone where exfoliation has taken place.

A. W. Hofmann.
E. Frankland.
F. A. Abel.

REVIEWS.

Treatise on Mills and Mill Work. Part I. By **William Fairbairn**, C.E., &c.—London: Longman. 1861. [Second Notice.]

We resume our consideration of the chapter on the flow and discharge of water.

Very useful tables as well as formulæ are given for the theoretical and actual velocities of discharge from rectangular notches, waste-boards, and weirs. Mr. Fairbairn then proceeds to the consideration of the friction of water in conduits and pipes:—

"In long tubes an increased retardation arises, which must be ascribed to the friction of the fluid against the sides, and it has been ascertained that this element of retardation, whilst independent of the pressure of the fluid, increases in ratio of the length of the tube, and decreases in the [inverse] ratio of the width or diameter. It also increases nearly as the square of the velocity.

For pipes of uniform size, and with no considerable amount of bending, it may be shown that the velocity of discharge

$$= v = \sqrt{\frac{2380\,hd}{l+54d} - \frac{1}{12}\cdot\frac{l}{l+54d}} \quad \dots \quad \dots \ (7)$$

or if h be not very small, neglecting the last term,

$$[v=]\sqrt{\frac{2380\,hd}{l+54d}} \quad \dots \quad \dots \quad \dots \ (8)$$

and if the pipes be very long,

$$v = \sqrt{\frac{2380\,hd}{l+54d} - \frac{1}{12}} \quad \dots \quad \dots \quad \dots \ (9)$$

where l = length of pipe in feet; d = diameter in feet; h = head in feet; and the constants have been derived from the experiments of Prony and d'Aubuisson.

Formula (8) very nearly coincides with that given by Poncelet—viz.

$$v = 47{\cdot}9\sqrt{\frac{dh}{l+54d}} = \sqrt{\frac{2300dh}{l+54d}}$$

The most convenient way in practice of estimating the retardation of friction in the pipes is to measure the head of water which is requisite to overcome the friction, without increasing the velocity of the current. In calculations of quantity, when the head h, necessary to generate the required velocity of exit, has been estimated by the rule for thick-lipped orifices already given, another head h_1 must be added, as necessary to overcome the friction, if the orifice is prolonged into a tube.

The height to overcome friction may be calculated from the formula,

$$h_1 = n\,\frac{l}{d}\cdot\frac{v^2}{2g} \quad \dots \quad \dots \quad \dots \ (10)$$

where n is the coefficient of friction derived from experiment. . . . .

We may combine this formula with the preceding formula for the discharge from a thick-lipped orifice, putting m = coefficient of resistance for the portion of tube next the cistern, and n = coefficient of resistance for the remainder of the tube, we then have for the whole head of water

$$h = m\frac{v^2}{2g} + n\,.\,\frac{l}{d}\cdot\frac{v^2}{2g} + \frac{v^2}{2g} \quad \dots \quad \dots \ (12)$$

or,

$$h = \left(1 + m + n\,.\,\frac{l}{d}\right)\frac{v^2}{2g} \quad \dots \quad \dots \quad \dots \ (13)$$

and

$$v = \frac{\sqrt{2gh}}{\sqrt{\left(1+m+n\frac{l}{d}\right)}} \quad \dots \quad \dots \quad \dots \ (14)$$

and putting a = area of orifice, the discharge =

$$Q = av \ \dots \quad \dots \quad \dots \quad \dots \ (15)$$

If there be bends in the tube, an increased element of resistance is introduced; if we put p for the sum of the resistances due to this source,

$$h = \left(1 + m + n\frac{l}{d} + p\right)\frac{v^2}{2g} \quad \dots \quad \dots \ (16)$$

$$= \left(1 + m + n\,\frac{l}{d} + p\right)\left(\frac{4Q}{\pi}\right)^2\cdot\frac{1}{2gd^4} \quad \dots \ (17)$$

These formulæ we have from Weisbach's 'Mechanics of Engineering,' from which the following table has been reduced and adapted to English measures. To use this table, look in the horizontal line at top for the nearest velocity in feet; in the vertical column underneath, and opposite the nearest number of inches, will be found the value of n required. Thus, for a velocity of 6 feet 8 inches per second, the coefficient n will be found to be ·0211, being under 6 and opposite to 8."

Table of the Value of the Coefficient of Friction n for different Velocities.

Inches.	Velocity in Feet.											
	0	1	2	3	4	5	6	7	8	9	10	11
0	∞	·0316	·0265	·0244	·0229	·0220	·0215	·0209	·0205	·0202	·0199	·0195
4	·0443	·0293	·0257	·0239	·0226	·0218	·0213	·0208	·0204	·0201	·0197	·0195
8	·0355	·0277	·0250	·0233	·0223	·0217	·0211	·0206	·0203	·0200	·0196	·0194
12	·0316	·0265	·0244	·0229	·0220	·0215	·0209	·0205	·0202	·0199	·0195	·0193

Another formula is brought forward, as deduced by Weisbach from sixty-three experiments, on the supposition that the friction is resolvable into two terms, of which one increases as the square, and the other as the square root of the cube, of the velocity. According to this formula, the head due to friction, in feet

$$= h_1 = \left(0{\cdot}01482 + \frac{0{\cdot}017963}{\sqrt{v}}\right)\frac{l}{d}\cdot\frac{v^2}{2g}.$$

A very convenient and useful table is then given, computed from Weisbach's formula, for pipes of various diameters, and for different rates of discharge. It must be remarked that Weisbach's formula is repeated at the foot of these tables, with the numerical constants rather smaller than they were given in the preceding text.

Mr. Fairbairn devotes two chapters to the construction of water-wheels. The subject is fully illustrated in every detail, and treated in a very practical and useful manner. The weight of our author's experience and judgment is evidently in favour of breast wheels as compared with both over-shot and under-shot ones. A description is given of the wheels of the Catrine Works, in Ayrshire, constructed by Mr. Fairbairn, on the high-breast system, about thirty-five years ago. During this time we are told that they have required little no no repairs, and they remain nearly as perfect as when they were first put up. No improvement of note appears to have been made during that time in the method of construction, if we except the ventilation of buckets, which seems to have been introduced shortly after the erection of the Catrine wheels, and applied to them in 1828.

In describing M. Poncelet's skilful modification of the undershot wheel, it is stated, on M. Poncelet's authority, that the duty performed is nearly 60 per cent. of the water-power expended—or about the same as the performance of Mr. Fairbairn's wheel with ventilated buckets and no sole, for low falls.

In treating of the turbine, the various modifications of that elegant machine are given in considerable detail. They are classified as—1st, Those in which the water passes vertically through the wheel; 2ndly, Those in which the water flows horizontally and outwards; and, 3rdly, Vortex wheels, or those in which the water flows horizontally inwards.

Turbines in which the water flows horizontally and outwards.

"In turbines of this class the revolving wheel is placed outside of the fixed wheel, so that the water directed by guide-plates on the inner wheel strikes the curved vanes of the outer wheel, and forces them round by pressure and reaction. The water is regulated by a cylindrical sluice fitting between the fixed and movable wheels.

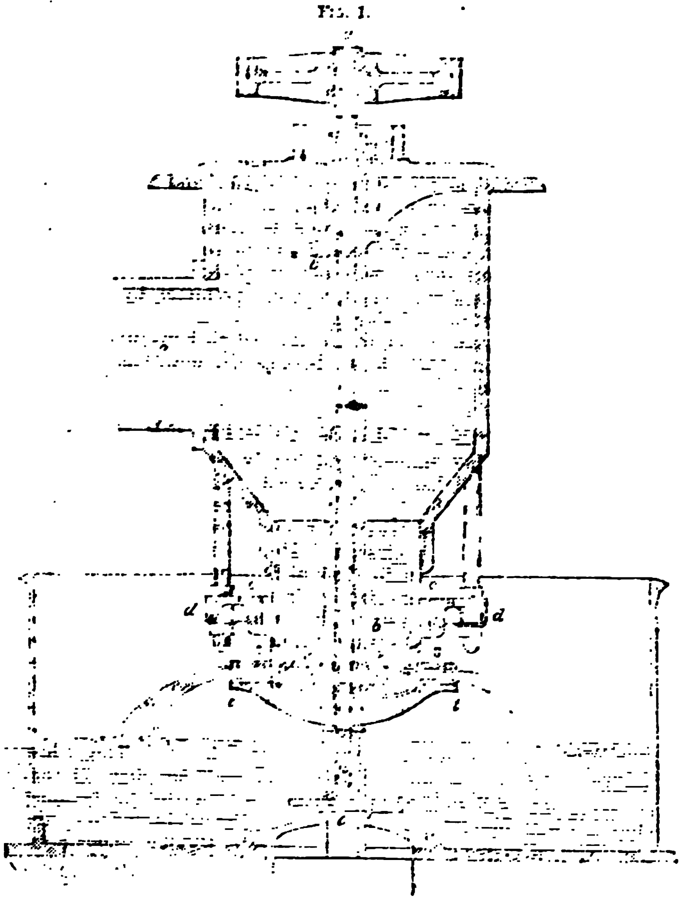
M. Fourneyron's turbine is the chief example of this class. Its advantages, as stated in M. Poncelet's Report to the Academy of Sciences at Paris, are the high velocity at which it may be worked without reducing its useful effect, its small size, and lastly, its capability of working equally well under backwater. From the experiments of M. Morin, the coefficient of useful effect appears to range from 0·60 to 0·80. On the other hand, it has to the full the defects of this class of machines, requiring the utmost nicety of design and execution, and being very susceptible to injury from small bodies carried into it by the water. It requires for its successful application both a large acquaintance with the principles of its construction and a considerable experience of its use: hence it will be unnecessary to do more in this place than to select for illustration one of the most successful instances of their application.

Fig. 1 represents a vertical section, and Fig. 2 a plan, of the celebrated turbine erected under M. Fourneyron's direction, at St. Blazier, for a fall of 354 feet. This small wheel, of only about 26 in. diameter, is employed in driving the machinery of a spinning factory of 8000 throstle-spindles, with the necessary preparing apparatus. In comparison with the work it has to perform, it is therefore of a size altogether unique.

The wheel consists of a cast-iron concave plate *t t*, keyed on the main axis *a a*; on this is fixed the annular wheel *s s*, consisting of an upper

> and lower plate of wrought-iron, in which are fixed the thirty-six curved diaphragms seen in the plan, Fig. 2. Opposite each of these curved plates, on the outer revolving wheel, there is a similar guide on the inner fixed wheel a a, which are carried on a massive cast-iron plate attached to the hollow tube b b, in which is placed the main axis. This plate not only sustains the guide-plates, but takes off from the main axis the weight of the water, and thus reduces the friction on the footstep. The cylinder c c slides up and down in the larger water cistern, and forms a circular sluice between the revolving and fixed wheel, by which, within certain limits, the discharge of water and the velocity of the turbine can be regulated. The sluice is raised or lowered by four rods d d, which are screwed above into the eyes of four pinions not shown. These pinions are geared into one [illegible] wheel, and in this way the four rods may be raised or lowered simultaneously. The supply of water is brought [illegible] feet in diameter and 12 [illegible] feet in length. The spindle works on a steel [illegible] in a footstep adjusted by gibs and cotters e. The turbine makes from 220 to 230 revolutions per minute."

Fig. 1.



The highest performance of the turbine ascertained by experiment appears to be from 75 to 80 per cent. of the water-power expended in driving it. This is not very different from the duty of the breast wheel with ventilated buckets on a large scale, which has been found to give a duty of nearly 75 per cent. of the water-power employed.

After some description of the water-pressure cylinder engine, the comparative merits of the different methods of rendering water-power effective are set forth as follows:—

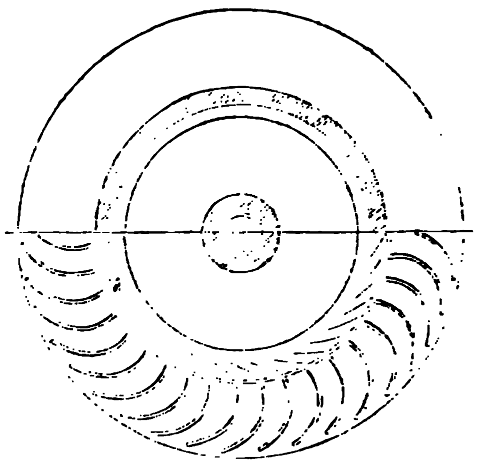
> "Hitherto the engines of this description, i.e., cylinder engines, have not [illegible] for pumping water, as the motion is exceedingly [illegible] of the water and the organic parts of the engine [illegible] of the power employed. To remedy this evil, it has been deemed advisable in some cases, wherever the fall is not too high, to introduce the water-wheel with cranks and spear-rods, communicating a reciprocating motion to the pumps in the shaft of the mine.
>
> In mountainous countries, where high falls descending from great elevations are found, the reciprocating engine is probably the best application for draining purposes, as the motion is conveyed direct from the [illegible] to the pumps, and that probably at the smallest outlay of capital where a supply of water is at hand.
>
> It is otherwise when large supplies of water on low falls are present. Then the water-wheel, with its machinery, is the most effective and the most economical application of the power.
>
> The recent introduction of the turbine may, however, effect a change in this class of machinery, as it is admirably adapted to high falls, and may be advantageously employed at a moderate cost. The great objection to its use in this form is the great velocity it attains on high falls, and the consequent reduction which would be requisite to work pumps at 10 to 12 strokes per minute, when the machine itself is moving at the rate of 400 or 500 revolutions per minute. This appears to be the only drawback, and it is not improbable that the single cylinder here described may, under certain conditions, be best adapted to meet all the requirements of raising water from deep mines with the aid of convenient streams on high falls."

The properties of steam are discussed at considerable length in a very useful chapter, containing (in addition to several other formulæ and tables, exhibiting the relations of pressure, temperature, &c.) the new and instructive results obtained by Mr. Fairbairn and Mr. Tate from experiments on the density of steam, already noticed in this Journal (*ante* p. 210).

The varieties of stationary steam-engines next come under consideration, and the economy effected by the use of high pressure steam, and long expansion, is very distinctly shown. After a practical chapter on boilers, a few pages on windmills complete the volume.

Altogether the work is full of instruction. It embodies the results of an extensive experience and of considerable study, in a shape that seems likely to prove very serviceable to the mechanical engineer and the millwright. Here and there (as we have previously had occasion to notice), there seems a want of that careful revision under which a book—of this character more especially—should pass before publication. The construction also of some of the sentences would be none the worse for a little editing. But as a whole we think the volume deserves, and will find, an honourable place in the standard literature of its special department.

Fig. 2.



An Appendix to the Fourth Edition of the Rudimentary Treatise on Clocks, Watches, and Bells, &c. By Edmund B. Denison, M.A., Q.C.—London: John Weale.

This appendix relates to a work which some short time ago was reviewed in this Journal, and the nature of which, as at that time we had occasion to show, is twofold,—part of the volume being of a scientific, and part of a controversial character. This appendix shares in the same divided nature, for while its early pages are devoted to chronicling the last improvements in clocks and watches, the remaining part is taken up by severe strictures on the Government Report, which we noticed at the time as affording some confirmation from independent sources about transactions in which Mr. Denison is too deeply interested for the public to regard his testimony as quite impartial.

To watch and clock makers the first four or five pages of this pamphlet, treating of escapements, will be of interest. The notice at page 3 of a new watch escapement appears to describe a remarkably simple arrangement, which, so far as can be judged from a written account only, must be at once well contrived and solid, so that for cheap watches, likely to be subject to great wear and tear, it seems well worth adoption.

Into the controversy on the Westminster bells we do not desire to plunge ourselves or our readers. Suffice it to say, that Mr. Denison displays considerable forensic skill in his attacks upon the evidence of the Astronomer Royal and that of Prof. Tyndall, and certainly hits some weak points in that of the former, while he treats with undeserved ridicule other important portions of the same evidence. It was not easy for Mr. Denison to dispose in the same way of the actual investigation and analysis made by Prof. Percy, nor does it suit his views to attempt to do so, since it is by the evidence of that gentleman that the unsoundness of the casting and inequalities in the composition of the metal are established. These defects are thrown upon the shoulders of the bell-founder, the legal experience of Mr. Denison having led him to conclude that, should the public once be induced to understand the bell-founder was in fault, they would forget that that fault is also shared by the gentleman under whose superintendence and control the work was done, under whose eye the casting ought to have passed when first fresh out of the mould, and for whose satisfaction, we contend, some such preliminary tests ought to have been applied as have, now that it is too late, proven indisputably that the bell ought never to have been hoisted.

Mr. Denison has gone so far in this appendix as to show that there can be two opinions as to whether the quarter bells are or are not in tune, but he has not shown or attempted to show that it would have been impossible by care and skill to detect, ere the bells were hoisted into their places, the existence of those defects which he now is most eager to point out and most ready to denounce. The pamphlet will interest those, and those only, who have watched this great, and let us add this lamentable controversy, from its commencement.

An Analysis of Ancient Domestic Architecture in Great Britain. By F. T. Dollman and J. R. Jobbins. Vol. I. Royal 4to. 81 plates.—London: Atchley and Co. 1861.

Since we last noticed the progress of this work, one half has been completed, in appearance it makes a most attractive volume, and is most carefully illustrated. The subject of our ancient domestic architecture is one deserving of every attention, although until the last few years but little has been worthily done with it. The ecclesiastical architecture of our island has properly received every kind of investigation, and the transitional changes in its style have been pointed out, with proper regard to their chronological succession. Its decorative features, both external and internal, have occupied the pen and pencil of many of our best architects, who have made it a labour of love to record in their pages thousands of examples of those creations which are so remarkable for their beauty of design, and which but for such preservation must have been lost to the rising members of the profession. The coloured wall decoration also of mediæval times, scantily existing, has been brought to light, and notice called to its excellence; and the changes in the arrangement of our churches at different periods of time have not been left unregarded. But it is remarkable that whilst the constructional design and decoration, and, in fact, all in connection with our ancient religious edifices, has received the amplest investigation, the existing time-honoured dwellings of the rich and middle classes should not have been similarly treated. The architectural relics of a departed age are among the chief landmarks showing the country's advance in civilisation, and go far to exhibit truthfully the social condition of the people, from barbarous times to those of enlightenment.

The publication within the last twenty years of illustrations of many noble dwellings of olden time, as well as those of the Elizabethan and Jacobean periods, has awakened attention to their vastness and magnificence, and to many historical associations in connection with them, yet they have all more or less been of that general character as to render them of but little use in a professional point of view, from the absence of minuteness of detail. It is from this circumstance that we look upon the present work, not only as a satisfactory addition to our stock of architectural information, but one of much practical utility. The volume is extensive in its subjects, and gives excellent representations in plan, elevation, section, detail, and perspective, from some thirty edifices, the dates of erection of which take the wide range from the early part of the twelfth to the beginning of the seventeenth century; and although many exist almost in their original perfection, yet it is to be greatly deplored that many are fragmental, and even what remains is not exempt from the spoils of time and the hand of the innovator. The abiding places of by-gone sovereigns and the palaces of dignified churchmen, we find, have furnished many plates, as well as existing monastic remains, and some which are no longer extant are here preserved, giving an additional value to the work. Several castellated structures have many remarkable portions shown, and those eleemosynary foundations which covered the land—proud monuments of the unbounded charity of our ancestors—figure here conspicuously as precedents that may be looked at for adaptation to the requirements of our time; and that other striking and picturesque feature of domestic architecture—the half-timbered dwelling—is represented by some good varieties.

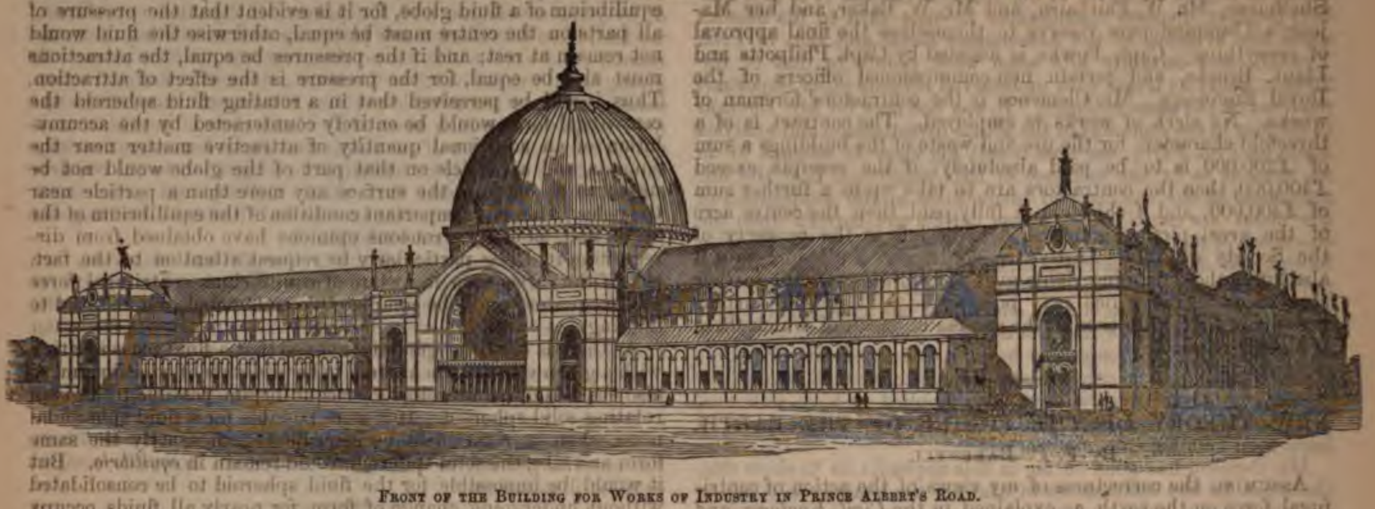
The accompanying descriptions, though not elaborate, are clearly written, and contain sufficient historical and architectural information to make them valuable; so that, looking at the work in every point of view, it cannot be considered other than one of much value, and if the second volume equals the first, no doubt can exist but that it will take its place in the library of the antiquarian, the archæologist, and the architect, by the side of the works of Britton and Pugin.

The numbers issued of vol. ii. are devoted to Penshurst Place, the ancient portion of which, we believe, till now, has escaped detailed illustration.

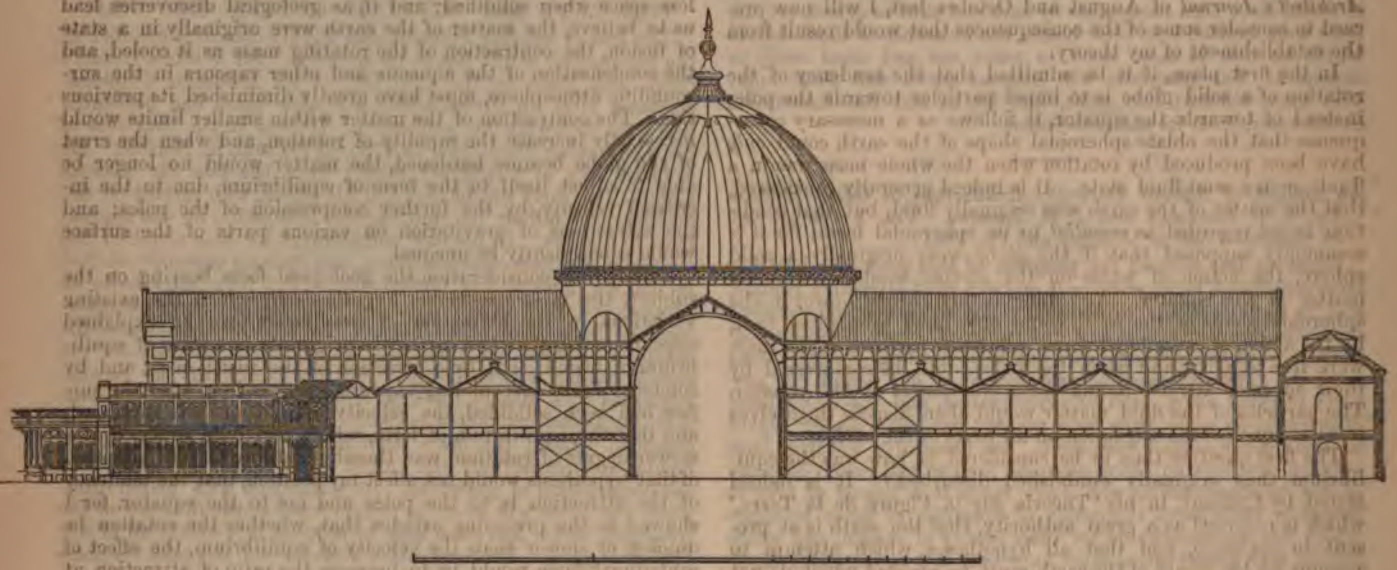
THE LATE SIR WILLIAM CUBITT, C.E., F.R.S.

The loss of another eminent and highly esteemed member of the engineering world has to be recorded. Sir William Cubitt's death took place on the 13th ult., at his residence, Clapham-common, after an illness which for some years had prevented him from following his profession. He was in the 76th year of his age, having been born in 1785, at Dilham, in Norfolk. Sir William was of a different family from the late Sir Thomas Cubitt. In early life he assisted his father, who carried on the business of a miller; but quitting this occupation he was apprenticed to a joiner. In his new employment he soon acquired the character of a first-class workman, and became especially skilled in making agricultural implements. Not long afterwards he adopted the trade of a millwright, and obtained ample employment in the erection of machinery. In 1807 he promulgated his invention—which has since been so commonly adopted—of the self-regulating windmill sails. Shortly afterwards he became connected with Messrs. Ransome and Son, the celebrated agricultural implement makers of Ipswich. Messrs. Ransome's business extended beyond the mere manufacture of agricultural implements; and accordingly Mr. Cubitt was extensively engaged in the construction of gasworks. In connection with prison discipline his name will ever be remembered as the inventor of the treadmill, which has since been introduced into nearly all of her Majesty's gaols. The innovation however did not take its place amongst the institutions of the country without being subjected to a large amount of ridicule and opposition. The first treadmill was erected at Brixton goal in 1817. In 1826 Mr. Cubitt settled in London as a civil engineer, and immediately was engaged in works of the most important character. In 1827 an act was passed for the improvement of the Norwich and Lowestoft navigation, and Mr. Cubitt was appointed engineer. The object was to open a navigation for sea-going vessels from Yarmouth or Lowestoft to Norwich. To effect this Mr. Cubitt united the river Ware with the Waveney, thence to the small lake of Oulton Broad, through Lake Lothing, with a passage onward to the sea, 700 yards long and 40 wide—Lake Lothing being thus formed into an artificial harbour, the tide-lock of which will admit vessels of 84 feet long and 21 feet in beam. This undertaking was completed in 1829. Amongst his subsequent employments he designed the South Eastern Railway, including the removal of the South Cliff by blasting, which feat was accomplished under his superintendence. He was officially appointed, being then President of the Society of Civil Engineers, to exercise a superintending watchfulness over the construction of the building for the Great Exhibition of 1851, in Hyde-park. He received the honour of knighthood for thus contributing his scientific experience in carrying out this national undertaking. The great works upon which Sir William Cubitt was engaged during the later period of his life were the London and York Railway, and the two large floating stages in the Mersey at Liverpool, one of which was illustrated in the volume of this Journal for 1855, and the new iron bridge across the Medway at Rochester.

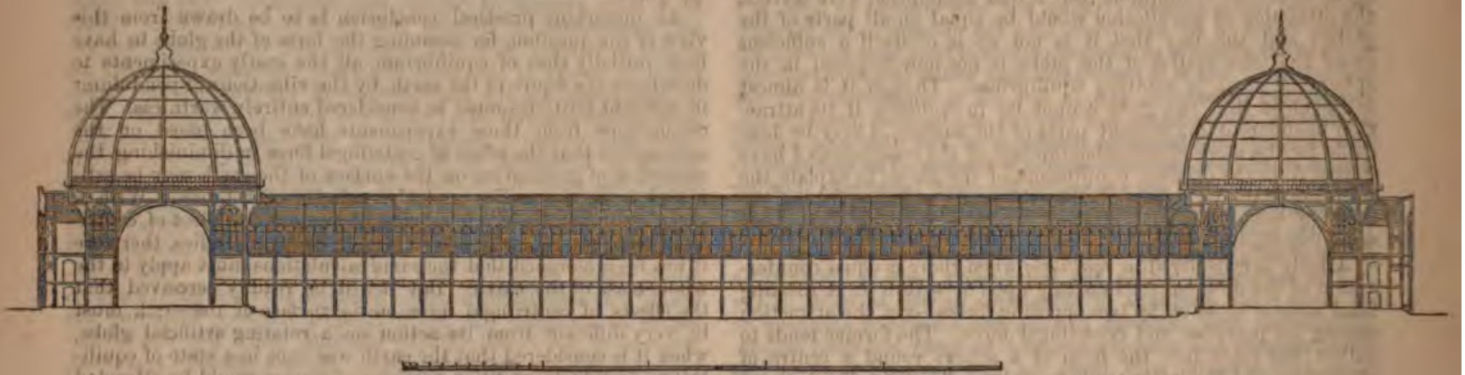
THE BUILDING FOR THE INTERNATIONAL EXHIBITION OF 1862.



Front of the Building for Works of Industry in Prince Albert's Road.



Section through one Dome from North to South.



Section from East to West.

In the number of the Journal for April last (page 99) we gave a description of the principal architectural features of the building for the Exhibition of 1862, accompanied with a geometrical elevation of the south or Cromwell-road front, and a general ground plan. We now give some further illustrations from the official account of the structure recently issued. During the progress of the building considerable improvements have been introduced in its architectural and structural details, and the works are now advancing with great rapidity, the whole of the nave being roofed in, and it will soon be possible to obtain a good idea of the general interior effect.

There appears no reasonable doubt, from the great progress already made, that the contractors, Messrs. Kelk, and Charles and Thomas Lucas, Brothers, will have completed their contract by the stipulated time, the 12th of February next. The whole responsibility for the nature and execution of the works rests with the contractors. Mr. Meeson, C.E., prepares the working drawings for them. All proceedings are submitted to Capt.

Fowke, R.E., who acts for her Majesty's Commissioners. He confers with a building committee, consisting of the Earl of Shelburne, Mr. W. Fairbairn, and Mr. W. Baker, and her Majesty's Commissioners reserve to themselves the final approval of everything. Capt. Fowke is assisted by Capt. Philpotts and Lieut. Brooke, and certain non-commissioned officers of the Royal Engineers. Mr. Clemence is the contractors' foreman of works. No clerk of works is employed. The contract is of a threefold character: for the use and waste of the buildings a sum of £200,000 is to be paid absolutely; if the receipts exceed £400,000, then the contractors are to take up to a further sum of £400,000; and if this sum is fully paid, then the centre acre of the great picture galleries is to be left as the property of the Society of Arts. Lastly, the contractors are bound to sell absolutely the remaining rights over the buildings for the further sum of £130,000, which may possibly be paid by the surplus receipts of the Exhibition, if the success be great, of which there is a good prospect.

◆

NEW THEORY OF THE FIGURE OF THE EARTH.

By F. C. Bakewell.

Assuming the correctness of my views of the action of centrifugal force on the earth, as explained in the *Civil Engineer and Architect's Journal* of August and October last, I will now proceed to consider some of the consequences that would result from the establishment of my theory.

In the first place, if it be admitted that the tendency of the rotation of a solid globe is to impel particles towards the poles instead of towards the equator, it follows as a necessary consequence that the oblate-spheroidal shape of the earth could *only* have been produced by rotation when the whole mass was in a fluid or in a semi-fluid state. It is indeed generally considered, that the matter of the earth was originally fluid, but that condition is not regarded as *essential* to its spheroidal form; for it is commonly supposed that if the globe were originally a solid sphere, the action of water on the surface would accumulate matter at the equator. According to my theory however, the spheroidal shape of the earth could only have been given to it, by the action of centrifugal force, when the particles of the mass were free to move, and when the poles could be compressed by their superior attraction, and force out matter at the equator. The particles of the fluid matter would then dispose themselves so as to equalise the attraction on all parts of the surface.

The first question then to be considered is, how was the equilibrium thus originally established disturbed? It is indeed stated by Clairaut, in his 'Théorie sur la Figure de la Terre,' which is regarded as a great authority, that the earth is at present in *equilibrio*, and that all hypotheses which attempt to account for the figure of the earth must be rejected which do not agree with that assumption. But if that assumption were correct, the attraction of gravitation would be equal on all parts of the globe; and the fact that it is not so is of itself a sufficient proof that the matter of the globe is not now disposed in the spheroidal form of rotating equilibrium. Though it is almost self-evident that the globe cannot be in *equilibrio* if its attraction be different in different parts of the surface, it may be desirable for the more clear understanding of the conclusions I have drawn from the original equilibrium of the globe, to explain the meaning of the term as applied to the earth, and to point out the state of independent equilibrium which a rotating fluid mass would assume *in space*.

A body is considered in *equilibrio* when there is equal counteraction of the different forces acting upon or within it. A rotating fluid mass is acted on by two opposing forces—viz. the attraction among its particles, and centrifugal force. The former tends to collect the mass into the form of a sphere round a centre of attraction, and the latter tends to make it fly off in directions at right-angles to the axis of rotation. When the attraction of gravitation is greatly in excess of centrifugal force, as on the earth, the result of the action of the two forces is to mould the sphere formed by gravitation alone into an oblate spheroid; by which change of form the accumulation of attractive matter near the equator counteracts the effect of centrifugal force; the quantity of accumulated matter being just sufficient to counterbalance the opposing force in every part of the globe. Under such circumstances therefore the earth would be in *equilibrio*, and, being in *equilibrio*, it would attract with equal force a particle placed anywhere on its surface. This equality of attraction on all parts of the surface is a necessary condition of the equilibrium of a fluid globe, for it is evident that the pressure of all parts on the centre must be equal, otherwise the fluid would not remain at rest; and if the pressures be equal, the attractions must also be equal, for the pressure is the effect of attraction. Thus it will be perceived that in a rotating fluid spheroid the centrifugal force would be entirely counteracted by the accumulation of an additional quantity of attractive matter near the equator, and a particle on that part of the globe would not be urged to fly off from the surface any more than a particle near the poles. This is an important condition of the equilibrium of the earth, and, as many erroneous opinions have obtained from disregarding it, I beg particularly to request attention to the fact, that if the earth were in a state of equilibrium, centrifugal force at the equator would be completely counteracted and reduced to nothing.

As there is only one spheroidal shape that a fluid mass rotating with a given velocity can assume to be in a state of equilibrium, so also there is only one velocity of equilibrium possible to a given rotating solid spheroid. If it were possible for a fluid spheroidal mass when in rotation to be consolidated in exactly the same form and size, the solid spheroid would remain in *equilibrio*. But it would be impossible for the fluid spheroid to be consolidated without undergoing change of form, for nearly all fluids occupy less space when solidified; and if, as geological discoveries lead us to believe, the matter of the earth were originally in a state of fusion, the contraction of the rotating mass as it cooled, and the condensation of the aqueous and other vapours in the surrounding atmosphere, must have greatly diminished its previous size. The contraction of the matter within smaller limits would necessarily increase the rapidity of rotation, and when the crust of the globe became hardened, the matter would no longer be able to adjust itself to the form of equilibrium, due to the increased velocity, by the further compression of the poles; and the attractions of gravitation on various parts of the surface would consequently be unequal.

Taking into consideration the geological facts bearing on the subject, the most reasonable hypothesis by which the existing variations in the attraction of gravitation can be explained appears to be, that the earth was originally in a state of equilibrium of fusion; that by contraction of the fused mass, and by condensation of surrounding vapours when cooling, after the surface had been solidified, the velocity of rotation was increased; and that the equilibrium of form, which had been adjusted to a slower degree of rotation, was thereby disturbed. The adoption of that hypothesis would not affect my position, that the tendency of the attraction is to the poles and not to the equator, for I showed in the preceding articles that, whether the rotation be quicker or slower than the velocity of equilibrium, the effect of centrifugal force would be to increase the ratio of attraction at the poles.

An important practical conclusion is to be drawn from this view of the question, for assuming the form of the globe to have been initially that of equilibrium, all the costly experiments to determine the figure of the earth by the vibrations of pendulums in different latitudes must be considered entirely worthless. The calculations from those experiments have been based on the assumption that the effect of centrifugal force in diminishing the attraction of gravitation on the surface of the earth may be estimated from the radius and the velocity of rotation. With a given radius and a given velocity of rotation the effect of centrifugal force can be easily determined in detached bodies, therefore it has been assumed that the same calculations must apply to the whole mass of the earth. But it will be readily perceived that the effects of centrifugal force on the surface of the earth must be very different from its action on a rotating artificial globe, when it is considered that the earth was once in a state of equilibrium, in which condition particles of matter would be attracted to it by gravitation in an equal degree in every latitude. The centrifugal force and the attraction of gravitation would be, in effect, in the same state of equilibrium as two equal weights in the opposite scales of a common balance. If into one of the scales an additional pound were placed, it would press downwards with the weight of a pound only, the attraction of the first weight being counteracted by the equal weight on the opposite scale. In the same manner, when the initial centrifugal force has been counterbalanced by the accumulation of attractive matter near the equator, the increase of that force by the increased rapidity of rotation would alone be effective; and to include the initial velocity of rotation in estimating the present amount of centrifugal force is to commit the same error as to include the original and equipoised weight in the scale with that of the pound subsequently added. Yet this is the mistake that has been made in attempting to determine the figure of the earth from the vibrations of pendulums.

Supposing the earth to be in the condition of equilibrium, and that attempts were made to measure its figure by the vibrations of a pendulum, first at the equator and afterwards near the poles, the results of such experiments would represent the earth's form to be that of a cylinder, for the vibrations would be equal in all latitudes. Assuming a small increased velocity of rotation to be then imparted to the globe, pendulum experiments would represent it to be a very elongated spheroid. If the initial velocity were increased one-fourth, the experiments might accurately represent the figure of the earth; or if, again, the velocity were further increased, they would represent it to be an oblate-spheroid of greater eccentricity than it really possesses.

Whatever changes the surface of the earth may have undergone since it received its present spheroidal orm, it must have, so to express it, a *nucleus of equilibrium*. The variations in the attraction of gravitation, therefore, only indicate the excess of the initial velocity of equilibrium, and the effect of centrifugal force in diminishing the weight of a body is the same as it would be on a solid sphere, previously at rest, when put in rotation about its axis with a velocity only equal to that excess. It is computed that the loss of weight of a body at the equator compared with the weight of the same body at the poles is equal to $\frac{1}{289}$th part of the whole; but, according to my view of the question, such computations, founded on the radius and the velocity of rotation, must be erroneous, because the variations in the attraction of gravitation are not caused by the initial velocity of rotation, but only by the excess of centrifugal force above the previously established equilibrium.

It would have been no sufficient objection to my hypothesis respecting pendulum experiments had they agreed exactly with the measurements of the figure of the earth by arcs of the meridian. Such an agreement might have been only a remarkable coincidence, which, as already observed, might take place supposing the velocity of the earth's rotation to have been increased one-fourth after equilibrium of the form had been adjusted. But the computations of the figure of the earth from the pendulum experiments do not agree with measurements of arcs of the meridian, nor with calculations founded on the ordinary action of centrifugal force. The disagreement is admitted to be greater than can be accounted for by supposed errors of observation; and the attempts that have been made to reconcile the differences have failed to do so. According to calculation, the attraction of gravitation at the equator should be $\frac{1}{289}$th part less than at the poles, but according to pendulum observations the difference amounts to as much as $\frac{1}{194}$th part, the latter fraction exceeding the former by $\frac{1}{590}$. It has been attempted to explain this discrepancy by supposing that the globe is denser in some parts than in others, and by attributing it to the spheroidal figure of the earth, which is imagined to increase the attraction of the rotating globe at the poles: thus in fact admitting my theory. But the endeavours to reconcile the observations of the pendulum with the computed effects of centrifugal force are admitted not to be satisfactory, and they have, indeed, little foundation but in the desire to make them agree; for, unless the differences can be reconciled, the errors are so great, as to be considered fatal objections to that method of determining the figure of the earth.

It has been stated as an objection to my views of the action of centrifugal force on the earth, that if bodies were attracted towards the poles, the water of the ocean would flow there, and leave the equator dry; but a similar objection would apply equally to the accepted theory, that the attraction is towards the equator; for it might be said that in such case the sea would accumulate there and leave the poles. The objection is not, however, of much weight in either case, when it is considered that the depth of the ocean, as compared with the diameter of the earth, is not greater than the film of moisture that adheres to the surface of an artificial globe, and that the ocean may therefore be retained in its present bed by merely local causes.

The greater attraction of gravitation at the poles than at the equator has, however, there can be little doubt, an important effect on the comparative densities of the atmosphere over the polar and equatorial regions of the globe. If the surrounding atmosphere, to a height of 50 miles, were a non-elastic fluid, the spheroidal nucleus of the earth, having greater attraction at the poles, would cause it to assume the figure of a spheroid of less eccentricity than would be due to the free action of centrifugal force. The elasticity of the air would however compensate for the variation of attraction, by increasing the density, instead of by changing its form, therefore it is reasonable to assume that the external configuration of the atmosphere corresponds with that of the earth, and that its normal density is proportioned to the attraction of gravitation in various latitudes on the surface of the globe. This hypothesis is to some extent confirmed by the observed difference of the pressure of the atmosphere at the equator and in latitudes nearer the poles, which is nearly in the ratio of the observed difference in the attraction of gravitation.

My theory of the action of centrifugal force on the earth would, if accepted, lead to further consequences than those I have indicated. The objections that have been raised to it are based on a consideration of the action of centrifugal force limited to separate particles of matter, supposed to be attracted towards a central point, without regard to the fact that the weight of each particle consists in its attraction to all other particles of the mass of the earth, and that any circumstances which diminish their attraction to one another diminish their weight. No attempt has yet been made to answer the arguments by which I have endeavoured to support my theory, and the more I consider them the more strongly do I become convinced of the correctness of the views I have explained, and to which I earnestly request unprejudiced consideration.

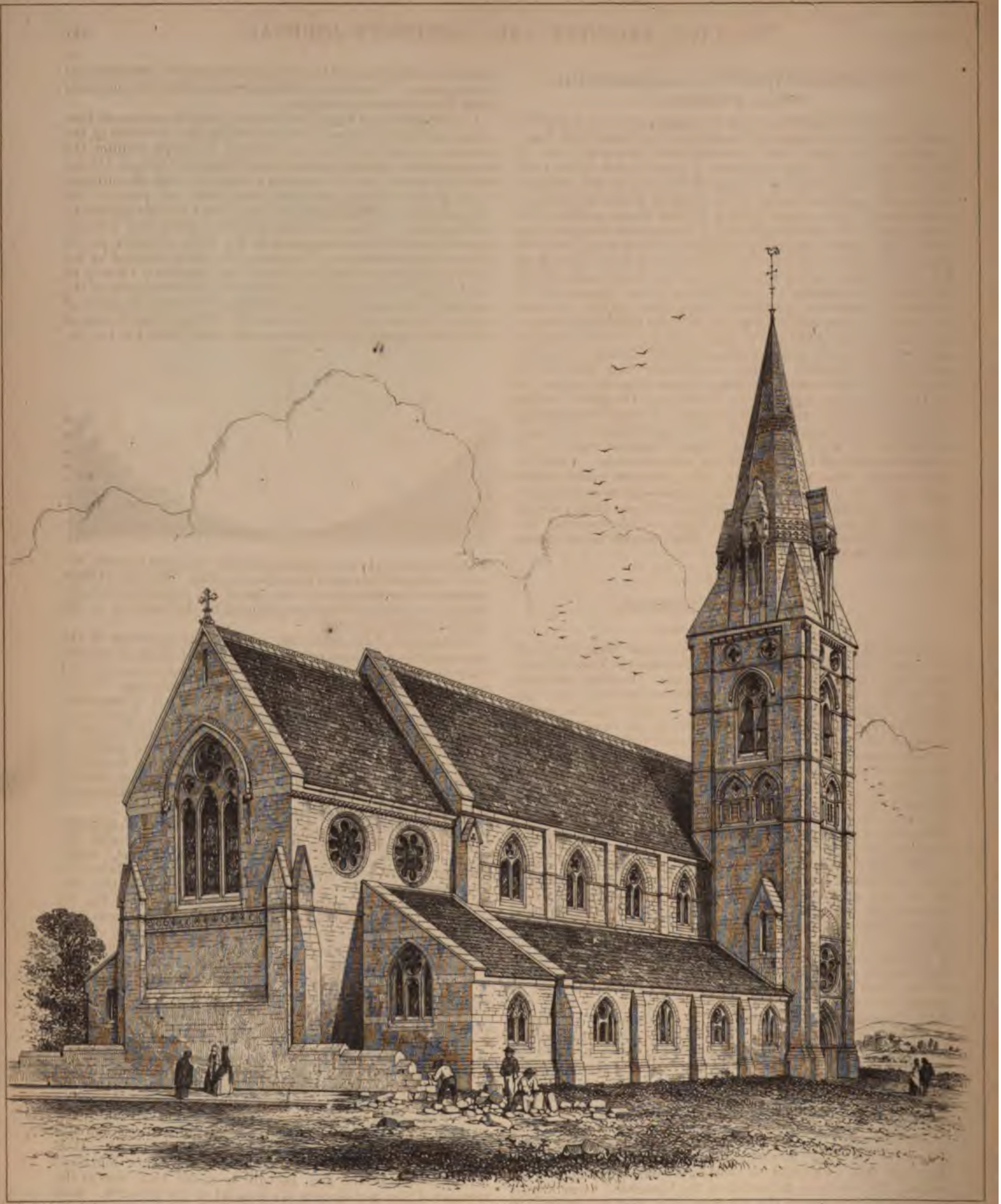
Hampstead, Oct. 15, 1861.

The Late Mr. Henry Austin, C.E.—On the 9th ult. Mr. Henry Austin, civil engineer, died in the prime of life, sincerely regretted. Mr. Austin was a pupil of the late Mr. Robert Stephenson; and assisted with the drawings for the London and Birmingham Railway, and the London and Blackwall Railway. He afterwards accompanied the late Lieut. Waghorn through Italy, at the time the latter was aranging the Overland Route. Mr. Austin acted as the honorary secretary of the Society for the Improvement of Towns, that was founded by Mr. Hickson and others: and, on the establishment of the first Board of Health (in 1848), was appointed secretary. He also acted for a time as joint secretary of the Sewers Commission. When the duties of the Board of Health were undertaken by the Privy Council, he was appointed inspector under the new act, and continued to hold that office till he died.

Discoveries at Suez.—The excavations for the canal, it is said, have led to the discovery at Gizeh of a religious edifice as vast as the Louvre, and which must have been constructed more than 5,000 years ago. At Karnack, also, a temple, the circuit of which is stated to be four kilomètres (2½ miles), has been discovered, and another at Edfou, containing twenty saloons. The walls of these latter edifices are decorated with sculptures, hieroglyphics, and paintings, still fresh, but nothing is said as to their character.

New Tunnelling Machine.—A machine for the purpose of tunnelling in rock, &c., is now making at the works of Hawkes, Crawshay, & Co. It is a ponderous machine, weighing about 50 tons, to be driven by steam-power, and intended to form a tunnel from 11 feet to 30 feet diameter. It is the patent of a Mr. Roberts: it is nearly completed, and will shortly be practically tested in the Claxton's Quarry, Gateshead.

A Machine for making Concrete.—A simple machine for this purpose is used in Germany. It consists of a cylinder 13ft. long and 4ft. diameter, open at its ends, and turning upon an axis inclined to the horizon. The stone and the mortar are thrown from a barrow into a hopper, which delivers them into the cylinder at its upper end. The mixture is effected by the rotation of the cylinder, whose lower end delivers the beton either into barrows or cars. The interior of the cylinder is smooth, and lined with sheet iron; the proportion of the materials is made by regulating the number of barrows of mortar and those of stone cast into the hopper. At one place the cylinder was inclined to the horizon one-thirteenth; it made from fifteen to twenty turns per minute, and the mixture was perfect. The cylinder was driven by a belt passing directly over its outer surface. Motion was given by an engine which worked at the same time a strong mortar mill. This machine easily made from 104 to 131 cubic yards in ten hours.



J. R. Jobbins lith.

Decr 1861.

St MARTIN ON THE HILL, SCARBOROUGH.

G. F. BODLEY, ARCHT

It remains to point out the algebraical properties of the Line of Pressure as derived from the Curve of Moments. And these will be found to be identical with what have long been recognised by mathematicians in the Line of Pressure as determined by analysis.

Let R be the total rise of the Line;
T the Horizontal Thrust; and
M the Moment of the Semi-arch.

$$\text{Then } \mathrm{R}\times\mathrm{T}=\mathrm{M}, \text{ and } \mathrm{T}=\frac{\mathrm{M}}{\mathrm{R}}$$

$$\text{Or, Horizontal Thrust} = \frac{\text{Moment of Semi-arch.}}{\text{Rise of Line of Pressure.}}$$

Taking the crown as the origin, let x (horizontal) and y (vertical) be the co-ordinates of the Line at any point;
l being the total load from the crown to the same point;
m, the moment of the corresponding portion of the arch;

$$\text{Then, } y\times\mathrm{T}=m \therefore y=\frac{m}{\mathrm{T}}=\frac{1}{\mathrm{T}}\int_0^x l\,dx \quad \ldots \quad \ldots \quad \ldots \text{(A)}$$

Or, rise of Line of Pressure is equal to Moment of Load divided by Horizontal Thrust. Differentiating both sides of (A), we obtain the following equation:—

$$\frac{dy}{dx}=\frac{l}{\mathrm{T}} \quad \ldots \quad \ldots \quad \ldots \text{(B)}$$

From whence it follows that the tangent of the angle made by the tangent of the Line with the horizon is everywhere equal to the load, measured from the crown, divided by the Horizontal Thrust.

Since the Resultant pressure at any assigned point may be resolved into the Horizontal Thrust=T, and a vertical element equal to the load supported, or=l, the direction which the above equation fixes for the tangent of the Line of Pressure is identical with the direction of the Resultant. The Resultant pressure must therefore be everywhere in a parallel direction to the Line of Pressure, even in cases where they do not coincide.

The differentiation of both sides of the equation (B) gives the following equation:—

$$\frac{d^2y}{dx^2}=\frac{\frac{dl}{dx}}{\mathrm{T}} \quad \ldots \quad \ldots \quad \ldots \text{(C)}$$

$\frac{dl}{dx}$ being the *rate of loading* at the distance x from the crown.

We infer from (B) that a concentrated load at any point will be attended with an abrupt change of direction in the Line, since the value of l will suddenly increase, and there must therefore be two values of $\frac{dy}{dx}$, and consequently two tangents meeting in an angle at the point where the load is placed; and also that when there is not a concentrated load at the crown of the Line of Pressure the tangent at that point will be horizontal.

From (C) it follows that when there is no concentrated load at the Crown the Radius of Curvature of the Line at the Crown is equal to the Horizontal Thrust, divided by the Rate of Loading. For $\frac{dy}{dx}$ at the crown will in this case be=0, and consequently the Radius of Curvature will be$=\frac{1}{\frac{d^2y}{dx^2}}$, which expression is $=\frac{\mathrm{T}}{\frac{dl}{dx}}$, or$=\frac{\text{Thrust}}{\text{Rate of Loading.}}$ Thus, if the Horizontal Thrust is 200 tons, and the rate of loading per foot forward at the Crown 5 tons, the Radius of Curvature of the Line of Pressure will be $=\frac{200}{5}=40$ feet.

But we must be careful not to confound the Curvature of the Line of Pressure with that of Intrados, as these are not necessarily the same, and may be very different. On the assumption that these curvatures are equal, the product of the Radius of Intrados and the Rate of Loading at the Crown is sometimes taken as being equivalent to the Thrust. This must be regarded as empirical, although in a well-proportioned arch it will often be not very far from correct.

The algebraical properties of the Line of Pressure above given will at once be seen to be those of a Curve of Moments drawn to a definite vertical scale suited to the multiplier $\frac{1}{\mathrm{T}}$: that is to say, a vertical scale on which a moment=T will measure the same as 1 foot on the horizontal scale.

The following equation expresses the general relation between the radius of curvature of the Line of Pressure at any point and the rate of loading:—

Radius of curvature,

$$\left\{=\frac{\left(1+\left.\frac{dy}{dx}\right|^2\right)^{\frac{3}{2}}}{\frac{d^2y}{dx^3}}, \text{neglecting sign}\right\}=\left(1+\left.\frac{dy}{dx}\right|^2\right)^{\frac{3}{2}}\times\frac{\mathrm{T}}{\frac{dl}{dx}}$$

Or, Radius is equal to Thrust multiplied by the cube of the secant of the angle of inclination with the horizon, and divided by Rate of Loading.

The above result exhibits a sufficiently well-known property of the Line of Pressure. The equation is sometimes, but inaccurately, made use of as applicable to the curve of intrados, and deductions have been made from it as to the form of extrados, when the line of intrados is a semi-circle, or other known curve.

Having now established the fact that the line obtained by our constructive process has all the essential properties (as exhibited in the foregoing equations) which mathematical investigators assign to the Line of Pressure, we need no further proof that the lines are identically the same, however distinct the methods by which they may have been arrived at.

In treating *one* line as the true index of the state of compression of an arch, and the just resultant of the pressure which in reality is diffused over the joints of the vaussoirs, it must not be forgotten that a certain very important condition has been taken for granted. We have assumed that each voussoir is *entire*, and fitted to receive a resultant pressure at any point and transmit it equally well in any direction. This condition ceases to be a matter of course in an arch composed of short voussoirs, ring above ring. Special care is therefore demanded in such cases, both in the cement and in the vertical bond, in order to secure the action of the compression on the arch as one deep ring rather than a bundle of smaller ones. If there were no cohesion binding the component rings, each must of course have its Line of Pressure, which, being contained within the narrow limits of that particular ring has of course a diminished rise. The aggregate thrust would therefore be much greater than if the voussoirs were either entire or connected by effective vertical bonding. But this is not all. There is another important element in the question, to explain which we must for the moment set aside the convenient and venerable fiction of the incompressibility of the voussoirs.

Each voussoir has a neutral axis. The Line of Pressure will pass above these neutral axes towards the crown, and below them towards the springing. The departure of the Line of Pressure from the neutral axis imposes a strain upon the voussoir of the nature of transverse strain, the measure of which is the product of the Horizontal Thrust and the vertical distance between the Line of Pressure and the neutral axis. This may be more readily perceived if we resolve the complex action that takes effect in the voussoir into two distinct actions, of which simple or uniform compression is the first. Consider, then, the voussoir as first sustaining uniform compression: the resultant thrust will therefore pass through the neutral axis. But the Line of Pressure is (let us say) one foot *above* the neutral axis, and the resultant thrust being therefore one foot below the Line of Pressure (*i.e.*, that much below the position that would give equilibrium), has not sufficient leverage to balance the moment of the load. The load will therefore continue to preponderate until it has (so to speak) *squeezed* out of the voussoir a supplementary moment of reaction to make good the deficiency. This supplementary moment must be equal to the product of the Horizontal Thrust and the vertical departure (1 foot) of the Line of Pressure, and it is thrown on the voussoir in the form of a transverse strain, causing (in the case we have imagined) compression above the neutral axis and extension below; so that it tends (in its measure) to bend the voussoir in such a way as to flatten the intrados. It will not generally follow that there is actual tension in the lower half of the voussoir, or even at its extreme edge; because a compression is at the same time taking effect at the neutral axis. The joint effect of these simultaneous actions will be a reduced rate of compression towards intrados, and an intensified rate of compression towards extrados. Of course, if the Line of Pressure had fallen below the neutral axis the result would have been the reverse.

Now, to sustain this inevitable transverse strain properly, each voussoir should be in a single piece, its depth being the entire distance between intrados and extrados. This becomes the more important as we approach the Points of Rupture, where the transverse supplementary strains become greatest. If the voussoir is divided in its depth into two, three, four, or more pieces, the intensity of the forces arising from the transverse strain will be twice, thrice, four, or more times increased, just as two or more planks placed one upon another will be more severely strained under a given load than a solid beam containing the same total depth of timber. In proportion, therefore, as we strengthen the vertical bond and approach the condition of a solid voussoir, we abate those intense partial compressions which throw such severe local strains on the material in addition to the general thrust.

In arches of brickwork this becomes the more important in proportion as the number of rings is increased. Mr. Brunel's bridge over the Thames at Maidenhead furnishes a most instructive example. This bridge consists of two elliptic arches, each of 128 feet span and 24 ft. 3 in. rise; thickness at crown, 5 ft. 3 in. It was first built of brickwork in mortar, but on slackening the centres the bridge was found absolutely too weak to stand alone. The arches were reconstructed with cement instead of mortar, and the result is a stable structure, which has now for six-and-twenty years sustained the traffic of the Great Western Railway.

Here the nature of the cement employed made all the difference. Since mortar is longer hardening than cement, a greater settlement might be expected in an arch where the former material was used, merely from the closing up of the joints. But this of itself would not account for the complete failure of the arch, which shows that the *bricks* must have undergone a destructive pressure. The secret of the success of the second experiment is evidently to be sought in the superior adhesion and tenacity of the cement, which accomplished what the mortar could not effect, by bonding together the rings of brickwork, and thus rendering the arch which they composed little (if at all) inferior to one with entire voussoirs.

While upon this part of the subject, it may be useful further to inquire into the intensity of the marginal strain thrown on the voussoir, as measured by the supplementary moment of which mention has been made.

Let D = Departure (measured vertically) of Line of Pressure from neutral axis;
d = depth of voussoir;
a = area of joint of ditto;
T = Horizontal Thrust;
$t\left(=\frac{T}{a}\right)$ = average intensity of Horizontal Thrust;
$t+c$ = intensity of Horizontal Thrust at margin of voussoir.

Then the Supplementary Moment causing transverse strain on the voussoir is $= \mathrm{T}\times\mathrm{D}$, and we want to determine $t+c$ or (since t is known) simply to determine c, in terms of D.

In the absence of a special knowledge of the material of the voussoir, we may assume that the elastic reaction is proportionate to the compression. On this supposition, the moment of resistance about the neutral axis $=\frac{c\times ad}{6}$. It must be observed that while half of this moment is created by a gradual increase of the average compression on the one side of the neutral axis, the other half is due to a corresponding *diminution* of compression on the other side. Thus the intensity of horizontal compression is $t+c$ at the margin nearest the Line of Pressure, $t-c$ at the other margin, and t at the neutral axis.

The Supplementary Moment $(= \mathrm{T}\times\mathrm{D} = t\times a\mathrm{D})$ must be equal to the above moment of resistance $\left(=\frac{c\times ad}{6}\right)$; and from this it appears that

$$t\times\mathrm{D}=c\times\frac{d}{6},$$

and consequently $c = 6\frac{\mathrm{D}}{d}\times t$;

and $t+c = \left(1+6\frac{\mathrm{D}}{d}\right)\times t$ is the intensity of compression at the margin of the voussoir.

Or, to find the amount by which the intensity of horizontal compression at the margin of the voussoir is increased, multiply the average intensity (t) by 6 times the vertical distance of the Line of Pressure ($\times 6\mathrm{D}$) from the centre of the voussoir and divide by depth of voussoir ($\div d$). All dimensions taken in feet.

It follows from this law that in a dry arch of *compressible* voussoirs the Line of Pressure cannot approach nearer to the margin of the voussoir than $\frac{1}{3}$rd of its depth, $\left(\text{or } \frac{d}{3}\right)$. For when this position is reached the compression at the further margin vanishes (being $= \left\{1-6\times\frac{\frac{d}{6}}{d}\right\}t=0$), and no further moment of resistance can be given out without actual tension. Any further departure of the Line of Pressure from the neutral axis than $\frac{1}{6}$th of d would therefore (in the absence of cement) open the joint. It will also be seen that in the cemented arch the contact of the Line of Pressure with intrados or extrados imposes on the voussoir a compression at one margin amounting to four times the average compression, and creates a *tension* on the stone and cement at the opposite margin of half the amount. One-third of the entire joint would in this case be in tension.

We cannot absolutely apply the theory of a dry incompressible arch to the actual case of a cemented arch of compressible material, so far as to say that the Line of Pressure really touches either intrados or extrados. Still, the preceding considerations have their weight, as making it additionally apparent how much the quality of the cement, as well as voussoirs, may have to do with the stability of a bridge. As an extreme case, we may refer to Sir Isambard Brunel's semi-arches constructed, without centres, in brick laid in mortar with bond of hoop iron and fir, which stood simply as brackets, one of them extending as far as 60 feet from its pier.

We have now pursued the examination of the arch as far as seems necessary to give such a general notion of the theory as may be practically useful in the construction of masonry bridges. If we have at all succeeded in what we intended, we have a comparatively short and simple (although correct) process, by which any one who is able to take out the quantities of a bridge, and to estimate their weight, will find little difficulty in drawing the Line of Pressure on the arch, and finding from it the amount of Thrust, and whatever else it may be needful to know. We hope also that the more scientific reader will have seen that our ready method is established by close and careful reasoning, and that if we have taken new paths we have not forsaken old truths. Those who would acquire a thorough knowledge of the arch will never get it from books alone, and we cannot pretend to give it them. We have only shown them an alphabet, with the aid of which they may spell out their learning from actual structures and the practical experience that is gained from real work.

FOREIGN PUBLICATIONS.

Die Mittelatterlieken Kunstdenkmale Dalmatiens, by Professor Rudolf Eitelberger von Edelberg. Vienna, 1861.—Few more interesting foreign publications than the volume the title of which we have just quoted have come under our notice. The shores of the Adriatic have been comparatively little explored for architectural purposes; and this work gives us some idea of what is to be found in a district no better known to us than is the East of Italy, and which, with all their wanderings far and near, most of our architectural travellers have omitted to visit. Dalmatia, a province under Austrian rule, and on the frontier of the Turkish Empire, stretches along the eastern coast of the Adriatic for a considerable distance, and five of its principal cities—namely, Arbe, Zara, Trau, Spalato, and Ragusa, have furnished the materials for the volume before us, which is illustrated by a very readable description, in German, and by some twenty plates and more than a hundred wood cuts. A description of Romanesque work furnishes the larger portion of the subjects for illustration, although one of the most interesting buildings described is the magnificent campanile at Spalato, of which the lower stories are Roman work, and display a richness and taste and ingenuity not exceeded by any of the better known fragments of Roman monuments with which we have been familiarised by travellers. The upper stories of this tower, Romanesque indeed, but harmonising most admirably with the Roman work, are not the least interesting of the objects represented in the work. The travelled architect turning over the pages of this book will find himself reminded of many very different localities and their peculiarities, as though the Romanesque style, which has acquired a certain local colouring in the different spots where it has flourished, had here been from some peculiar combination of circumstances thrown into all the varied forms of various, and often distant provinces. For instance, at Zara we have a façade such as recalls forcibly all the best features and peculiar arrangements of buildings at Pisa; from Arbe we get a campanile containing certain forms which were far more prevalent in the South of France than elsewhere; and from Trau we have a doorway reminding one a good deal of English Romanesque, such, for example, as that at Rochester. The plates are very well got up, and include, besides what we have alluded to, examples of a later style, closely resembling Venetian-Gothic specimens of jewellery work, carvings, and other matters of detail. We strongly recommend it to students of early architecture.

Révue Générale.—A very remarkable part of this journal has lately appeared, comprehending four monthly numbers, and with contents of a nature seldom attempted in any periodical. The larger part of the issue is devoted to the late competition for the Paris Opera House, and includes a full account of that undertaking, illustrated by plans, sections, and views of no fewer than eighteen of the designs submitted, the whole being so complete as to form a valuable manual of reference for those who propose to engage in the arduous task of the preparation of designs for a large theatre. Mr. Daly criticises the circumstances and conditions under which the competition was first opened very minutely and temperately, and compared it with the competition in London in 1857 for the public offices. Here, by-the-bye, he curiously enough commits an error in the names of the judges, David Roberts being entitled member of the Royal Institute of British Architects, in place of member of the Royal Academy; and the name of Mr. Burn, the architect, who was one of the judges, and upon whom, with Mr. Brunel, fell much of the labours of the investigation, is left out. The advertisement and programme which invited preliminary designs or sketches, and not completed designs for the opera, are given *in extenso;* and, short as was the time allowed for the preparation of plans—only one month—no fewer than 171 designs were sent in, forming a thousand drawings, computed at a value of from two to three hundred thousand francs (£8,000 to £12,000). Out of these designs five were chosen, and among the authors of these five a second competition took place. These gentlemen were Messrs. Ginain, Crepinet and Botrel, Garnaud, Duc, and Garnier, two of them, M. Crepinet and M. Botrel, having been prizemen in the English competition. The second competition was based upon an elaborate programme prepared with the utmost minuteness—a document that cannot fail to be always of value to the architectural profession—this also is given in full in the *Révue.* The result of this final competition was that the design of M. C. Garnier was unanimously chosen, and is, we presume, being carried out. The illustrations of this competition comprise the plans of all the 18 designs chosen by the editor for this purpose reduced to a small and uniform scale and excellently engraved on wood, and many of them present brilliant examples of that skill in planning for which our French neighbours are so famous. Of the five premiated designs in the competition, only two are engraved, and the successful design do not appear, nor, so far as we can make out, any other of the five submitted in the second competition. It is to be hoped that all these will hereafter be published; but in the meantime architects will find the selection actually given to exhibit great talent. English architects will find especial interest in the design which is the joint work of Messrs. Crepinet and Botrel, who have both, as has already been mentioned, achieved distinction in our own country. The elevations, sections, and views furnished are not of equal interest with the plans, nor of the same degree of excellence; they are given only in certain cases, and, for the most part, are engraved on steel.

The 'Dictionnaire de l'Académie des Beaux Arts.'—'Dictionary of the Academy of Fine Arts' is a publication to which it is desirable to draw attention. It promises to be a voluminous and valuable work, and will embrace explanations of all the words belonging to the teaching, the practice, and the history of the fine arts. It is illustrated by engravings on steel, and appears, so far as the specimen before us is concerned, to have a decided leaning to Classic rather than to Mediæval art. A very well written though brief treatise on acoustics, as applied to buildings, occurs among the words under the letter A.

Il Giornale del Ingegner, Architetto, ed Agrouomo.—'The Journal of the Engineer, Architect, and Land Agent' is a periodical, the very existence of which cannot fail to interest our readers when we state that it is an Italian periodical published at Milan, and is now in its ninth year. It appears to be published in bi-monthly parts, each containing two numbers, comprising some 120 octavo pages and a few illustrations, and the price of publication is very moderate. The illustrations are but indifferently executed; the letterpress is, however, respectable, but the papers seem most of them too lengthy to admit of our extracting one entire as a specimen. The fact of such a journal having existed for eight years during the Austrian occupation of Lombardy is very interesting; and we look forward to the possibility that, with new activity aroused in a country long since famed for the skill of both its engineers and its architects, we shall hear of great architectural and engineering works, and shall find in this journal a description and a record of them. We find, among the original articles, some on existing architectural works—such as the cathedrals of Casale and Novara—others treating of the fine arts theoretically, and others on various matters of railway and hydraulic engineering. Extracts from other periodicals, and digests of their contents, are given to a considerable extent, and a great deal of miscellaneous information; the whole being, however, well adapted to inform Italian readers of the course of works in adjacent countries. We shall take another opportunity of saying a few words relative to those articles in the *Giornale,* which gives accounts of works actually in progress—or works in contemplation—in the Italian kingdom.

HIGH SPEEDS ON RAILWAYS.

The lamentable experiences of the year now drawing to a close seem to have brought home to most minds a feeling of something wrong in the system or working of railway traffic. Without any well defined general conviction as to where the fault lies, or in what way the evil may be abated, there is a very prevalent suspicion (at least) that railway travellers in this country are at the present day exposed to an amount of personal risk, not only formidable, but excessive, and such as might be and ought to be avoided.

Upon the subject of "High Speeds" Mr. George Robert Stephenson, C.E., has recently addressed an able letter to the President of the Board of Trade. On such a subject the expression of any clearly-formed and positive opinion cannot fail to command a hearing. The opinion of a man who may be presumed to have a special acquaintance with railway matters claims further to be listened to with respect, whether we are prepared at once to adopt his conclusions on every point or no. Mr. Stephenson indicates high speed as the main cause of the increase of railway accidents. He is entitled to the more attention in assisting such a view when we reflect that it is diametrically opposed to the bias of his own personal interests, he being one of the largest constructors of locomotive engines in England. The issue is joined in the opening sentence without hesitation or compromise —"The time has arrived when, in my opinion, public attention ought to be directed to a subject which involves an immense sacrifice of life and property. I refer to the excessive speeds which are being employed on our railways.

Mr. Stephenson thus defines what he considers implied "high speed"—

"High speed upon any particular line of railway does not alone mean the high speed of any one express or special train. The high speed of one train in the course of a day involves, it is to be remarked, the increased speed of all the trains upon the line and system on which the one train works. Just as the steepest gradients upon a line govern the weight of a train which is to be drawn along that line for its whole length, so the speed of the fastest train must govern and regulate the speed of every other train that runs upon its line."

Here Mr. Stephenson demonstrates the probable danger consequent upon a mineral train being followed by goods and ordinary passenger trains, all hastening to avoid being overtaken by a high speed train; the mineral train having to be accelerated at intervals, and shunted at great risk of danger. Again, in the same pamphlet Mr. Stephenson says:—

"On any line well supplied with traffic the circle is kept up all the day round, and all the day round the lowest speed must be governed by the highest. On the London and North Western Railway, for example, there are upwards of 1,100 trains of every description running every day over their lines. It is obvious that the speed of each of these between stations must be regulated by the speed of the trains immediately preceding and immediately succeeding, and that the speed of the whole must be governed by the speed of the fastest train which runs upon the line.

"High speed, it is also to be observed, implies irregular speed. Velocity, as we all know, is ruled by gravity; and the same velocity cannot be attained with the same load over an inclined plane that can be attained over a horizontal line. When the speed of a train, therefore, is taken at an average of say forty miles an hour, by as much as that speed is necessarily diminished over certain portions of the line, by so much will it be increased over other portions. The high speed which averages forty miles an hour thus inevitably becomes an excessive speed of fifty, fifty-five, and even sixty miles an hour upon certain portions of the line traversed. In the case of an accident which I shall hereafter refer to, a train, timed to run at an average rate of less than forty miles an hour, was reported by one of your inspectors to have been travelling at the time of the accident at fifty-five miles an hour, if not more."

High speed is taken, first, to imply irregular and excessive speed; and, second, to necessitate increased and needless velocities over the whole system on which such speeds are employed."

If it were attempted to find a limit to the speed that may be employed on straight lèvel well-laid rails with wheels properly placed and coned, the task would be found an exceedingly difficult one, requiring extensive experiments and much sound calculation. A belt remains on a pulley at very high velocities when the belt is properly adjusted and the pulley rightly coned; if the pulley was cylindrical the belt would soon run off. Now, a railway may be considered an iron belt, but stationary, while the coned wheels act the part of the pulley, but moveable. As the belt in this case is not elastic, the middle is taken out, the two rails remain and operate upon the same principle as if the belt were complete. The middle of the pulley being dispensed with, flanges often very clumsily make up the deficiency.

The first pair of wheels of a carriage is kept to the iron belt, and steered by the last pair on a straight level railroad. While it involves no risk to travel at the rate of 120 miles an hour, the road being clear, straight, and level at all points, with well-constructed carriages and properly coned wheels, the risk becomes very great to travel at the rate of 50 miles an hour when the road is composed of straight lines and circular arcs, and at the same time passing over all sorts of gradients.

We contend that no portion of a railway should be composed of straight lines and circular arcs when a uniform speed of 50 miles an hour is to be employed. Without at present entering into the investigation of the curve and the proper coning and disposition of the wheels to suit different speeds, it is easily shown that a track composed of straight lines and circular arcs is not a safe one when the velocity is high, say more than 38 miles an hour. Supposing, however, that perfection in the permanent way and the wheels for high speeds be obtained, how long would this theoretical state of perfection last? We apprehend that in a short time the excessive wear and tear due to the mass of a railway train moving at such high speed would reduce the most perfect railway to a state bordering on dilapidation.

But the science of the subject has little to do with the mercantile question or practical working of existing railways well described by Mr. Stephenson. He says:—

"The few need very occasional opportunities of reaching very distant places with excessive speed. The many require very frequent opportunities of reaching neighbouring places with moderate speed. Now, the excessive rate of speed of one or two trains, which of necessity increases the expedition of all the trains upon the system, of equal necessity diminishes the opportunity of running stopping trains. Thus, the high speed of one or two trains carrying a few passengers 200 or 300 miles precludes a railway company from developing its local traffic; and thus the most profitable part of a railway company's business is lost upon those lines on which high speeds prevail.

Two illustrations may be given in proof of this position. The London and Brighton has through trains running at high speeds. It also has acquired a very heavy local traffic between London and the Crystal Palace and intermediate stations. But at what cost has it maintained its high-speed trains conjointly with its local traffic? Why, at a cost which virtually sacrifices all the profit its local traffic would produce. In order to maintain its high speed trains, the London and Brighton has been obliged to lay down other lines of rails for its Crystal Palace traffic. It has, in fact, constructed for this traffic a new railway and a new entrance into London. The construction of this new railway and new terminus has absorbed a new capital, and the absorption of that new capital has prevented any corresponding increase of dividend to the Brighton Company. Thus the traffic which might have been, and which was expected to prove so profitable to the Brighton Company, has been sacrificed to preserve high speeds. So with the London and North Western. The London and North Western has been gradually developing a most enormous mineral traffic. It now brings to London no less than 500,000 tons of coals a year. But this mineral traffic, it is found, cannot be conveniently carried on together with the high-speed traffic of the line. The London and North Western Company has, therefore, been compelled to lay down a new line of rails for its goods traffic in London. That new line of rails involves outlay of new capital. The outlay of new capital absorbs the increased dividend which would otherwise accrue to North Western shareholders from their largely increased revenue from minerals and goods. And all this results from the necessity of maintaining the high speeds.

High speeds, therefore, involve great outlay of capital in order to preserve and to work trafic which is inconsistent with high speeds. But the outlay of capital is not the only evil consequence resulting from high speeds. High speeds necessitate large additions to working expenses. I use the words "large additions" in the most ample sense those words imply. All who are interested in railway enterprises know the importance of working expenses. They absorb half, and sometimes more than half, the receipts of a railway. But working expenses are most inordinately increased by high speeds. There is no item of working expenses which high velocities do not largely add to. Take, in the first place, the engine. To attain and to maintain high speed, the engine employed must be of excessive power—excessive power implies great size. To attain great speed the first essential is great evaporation. Great evaporation can only be attained from a great heating surface. A great heating surface necessitates large boiler space. Large boiler space necessitates a large-sized engine; and large size in an engine necessitates corresponding strength and weight in every part of the machine. But this is not all. To afford a large amount of heating power a large quantity of fuel is requisite; and this large quantity of fuel requires a corresponding means of conveyance—this implies a large tender. A large tender, holding a large supply of fuel, implies a heavy draught; and in proportion as the draught of this dead weight is increased, by so much must the weight of passengers and goods be diminished. Here, then, you have not only a heavily increased first outlay upon an excessively large engine to work a train at high speed, but you have a perpetual outlay upon the working expenses of that engine, accompanied with a corresponding diminution of the profit of the train which the heavy engine draws.

If these were the only additions to working expenses resulting from high speeds, railway companies might bear the outlay. But it is to be borne in mind that the working of an excessively heavy engine at an excessively high speed necessitates a correspondingly strong road. What ordinary permanent way can be expected to bear an engine and tender of fifty tons weight, rushing over it with a train at the speed of fifty miles an hour? To carry such a train the permanent way must not only be of the highest character and in the most perfect state of repair, but the rails should be of extra weight, and should be laid with all the best appliances conducive to their strength. When we hear of 'fished joints,' and of a hundred other recent improvements for permanent way, what is meant but better arrangements for high speeds? But those arrangements only require outlay; and by as much as such outlay increases working expenses, so much do shareholders' profits diminish.

But, even under the most perfect system, high speeds necessarily prove an enormous source of loss to railway companies in the form of working expenses. Under the head of 'Renewals of Permanent Way, and Rolling Stock,' shareholders pay largely for high speeds. It is not only that the rails are worn and torn by the action of the heavy engines and carriages travelling at these immoderate rates, but they are literally ground by the application of the ponderous breaks which are applied to check high speeds on approaching stations, in descending gradients, and on other occasions. Nor is this source of expenditure limited to the results occasioned by fast trains. Every other train that is forced to escape the fast trains by shunting into a sliding involves the company in a certain charge for repairs and renewals by that very act. Next to high speed, nothing is so injurious to rolling stock as shunting. The carriages and trucks are knocked against each other with great violence, and are inevitably damaged by the concussion. The wheels also are knocked against the rails and points, which receive inevitable and permanent damage thereby. The larger and heavier the train to be shunted, the greater is the damage. And not only do the carriages, the wheels, the rails, and the points suffer, but the engine and tender, which have to perform this violent act of shunting a train backwards into a siding, must of necessity be injured. The act itself consists, in fact, of a series of percussions, and whilst every shock inflicts injury, is is obvious that the force of the concussion operates the most severely on the delicate though powerful machine which has to inflict the blow. Nor do wear and tear comprehend the only losses which shunting occasion. There is the loss of time occupied in the operation—often a very serious loss; and there is the loss involved in the expenditure of power—an expenditure, be it observed, which does not advance the train one inch in the direction in which it ought to go.

In every other item which enters into working expenses, it is obvious that the outlay must be greater in respect of the high speed than of any other train. The carriages must be of the best character, and in the most perfect condition. The guards and drivers must be the best and most skilful servants of the company. The train must be better attended to at every station at which it touches. In every item of outlay the high speed train costs more in proportion, in fact, to work than any other train upon the line. Who pays for this additional expense? The train can carry no goods, no parcels, no carriages, no horses, and only a limited number of passengers. In certain of these fast trains the passengers used to pay a small and inadequate addition to their ordinary rate of fares; but even this, it would seem, is now objected to, for the limited mail to Scotland (the fastest train in the world) now carries its passengers to Scotland at first and second ordinary fares."

It cannot be disputed that high velocities entail a high rate of working expenses, as we find Mr. Stephenson insisting. We can can well understand that a moderate rate of speed would accord with a moderate outlay, and that if the traffic were the same the net revenue would be correspondingly increased.

We consider 40 miles an hour to be a dangerous speed passing down a straight gradient, and then turning to move on a circular arc. The axles of the wheels should be parallel when a carriage is moving on a straight level road; this is not the case when a carriage is moving in safety on a curve. The axles, if produced, should pass through the centre of the circle of curvature at that joint. When the axles are near each other and the circle of curvature great, the parallelism of the axles requires but little adjustment moving on a curve at very high velocities.

The trucks employed under the long American cars contain four and sometimes six wheels. The axles are parellel when the car is moving on a straight level road, and there is an arrangement when the car is moving on a curve that accommodates the axles to the motion. This is effected by springs—and what is termed a lateral motion-bar, connected with a ring-pin. But however well the road and running gear are prepared for high speeds, accidents occurring from collisions of trains going at different speeds are not so easily guarded against. Mr. Stephenson, at page 17, remarks that "The dangerous character of these high speeds is, I think, very easily demonstrable. Apart from accidents which occur to individuals from their own neglect, railway accidents generally may be classified as occurring either

(1) From the failure of an axles, a wheel tire, or some other portion of the running gear of a train.

(2) From some defect in or obstruction of the permanent way, or

(3) From a collision of trains going at different rates of speed."

The question is, Have we sufficient skill and science to remedy the defects, prevent the failures, and overcome the obstructions referred to in paragraphs 1 and 2? Mr. Stephenson's remarks on the subject of paragraph 3 deserve attention:—

"And this brings me, naturally, to consider the other class of accidents most prolific of disaster—those which rise from 'collisions,' and which are usually attributed, in the reports of your inspectors, to some neglect on the part of those who have the management or conduct the trains. On a close examination of the circumstances of these cases, it will almost uniformly be found that they rise from irregularities in the despatch or running of trains going at varying rates of speed. But what is the cause of these irregularities? Why are trains running at irregular speeds despatched at intervals so short that there is any possibilty of collisions? Simply because the arrangements of a line are necessarily controlled by the running of those few fast trains, to the expedition of which all other traffic arrangements are made subservient. The time of every train—the time of running, the time for stopping, the intervals of departures, and the intervals between arrivals—all are shortened, and sometimes dangerously shortened, by the necessity of escaping the 'limited mail' (limited in everything except its velocity). Four or five minutes make all the difference. The cattle train, which was overtaken and smashed to pieces at Atherstone had its three, four, or five minutes to escape, by shunting into a siding, the limited mail which was rushing after it at a high velocity. One minute in that case made all the difference. It was the very tail of that train—its very last carriage—that was caught whilst in the act of 'shunting,' and we all know what were the disastrous effects.

But the blame in this, and in other cases, was placed, as usual, on the shoulders of subordinates. In all these cases the public are instructed that 'the proper caution was not given;' or 'the driver was not suffficently vigilant in his look out;' or 'the signals were not properly exhibited;' or, 'the whistle was not sounded;' or, 'the breaks were not properly applied;' or, 'the breaks were not powerful enough; or, there was imperfect communication between the driver and the guard.' I submit that these are almost imperfect and unsatisfactory modes of accounting for accidents which occur from one main cause—the necessity of regulating the the running traffic of a line so *finely* as to render occasional collision unavoidable. No doubt accidents may be greater or less in degree—no doubt actual collisions may even be avoided—by greater care, greater attention, greater supervision, greater power, greater skill, than any one can expect to be at all times employed in the conduct of a train. But I contend that so long as trains run, as trains are now forced to run, at irregular velocities, and with such trifling intervals between them, it is inevitable that fast trains must occasionally overtake slow trains, and that accidents must be the result.

Before we attribute such accidents to negligence, it is obviously proper to consider what degree of duty we put upon the men we blame for these collisions. A driver is instructed to run his train at an average of 40 miles an hour. That average means 50, or 55, or even 60 miles an hour on good travelling ground (where, it is to be observed, these collisions most generally happen). Now, what is the position of a driver running his train at the rate of 50 or 55 miles an hour? In the first place, his attention is necessarily absorbed in the working of the line. His whole time is absorbed in looking out for signals. Among the various suggestions with which the reports of your inspectors abound, it is recommended that every engine should have a small looking-glass attached to its sides, so that the engine driver may see what is passing behind him without the necessity of turning round! The very suggestion shows that he is expected to keep his attention invariably directed to his immediate work. But, if so, what time has he to consult his looking-glasses? The driver is scarcely able even to attend to his engine; he has no time to attend to what is passing in his rear. The fact is, that the driver of one of these high-speed trains has not an atom of time—not a single breathing instant—to give to anything beyond the signals on his road. In the case of accidents occurring to high-speed trains from broken flanges or otherwise, it constantly appears that so entirely was the driver's attention absorbed that he did not become aware of the accident until long after it occurred."

Mr. Stephenson argues that there is not too little, but too much interference on the part of the Government, inasmuch as the timing of the limited mails is fixed by the Post-office, and governs the timing of all the other trains. With regard to the limited mails themselves, it will at once be admitted that the combination of high velocities and very infrequent stoppages is undesirable in any train that is permitted to carry passengers, especially in the absence of an efficient system of communication between guard, passengers, and driver; the latter of whom, however, can know but little of the danger that may be at hand while rushing through the air at such fearful velocities as is proved by the testimony of the drivers themselves.

Accidents from fault in the running gear or the permanent way will usually be aggravated by high speed. Such accidents may also freqently be attributable to excessive speed, meaning by this term a speed which overtasks the capabilities of the road and running gear. But if the manufacture and condition of the carriages, the careful inspection of the wheels, the fishing of the rails, and the construction and maintenance of the permanent way generally, can be kept fairly up to the standard required for high speeds, the question becomes, of course, modified.

With regard to collisions, there can be no question that a system of high speeds multiplies the chances of collision, especially when train follows train in quick succession. The dangers of this nature, arising from heedless shunting, or the hindrance or break down of a train ahead, rapidly increase with the increase of speed.

We fully concur in Mr. Stephenson's opinion as to the risk of collision being much increased by high speeds. The interval that is sufficient for low speeds becomes perilously small for high speeds, and the same yet applies more forcibly to the distances at which signals should be shewn. We cannot give a better illustration of this fact than by referring to the late disastrous accident on the London and Brighton Railway, in which case the interval of time between the trains was known to be seriously too short, and the speed of one of the trains too high—a remarkable instance of the necessity for Mr. Stephenson's warnings, as expressed in his pamphlet, which had been issued only a short time previously to the occurrence of the accident referred to.

Increased break power for the fast trains will, by its proper application, go some way towards lessening the danger of collision, but no break has yet been devised that can pull up a high-speed train in a very short distance; and it is to be hoped that such a break never will be devised, as we feel certain that its effect in stopping the train would be as disastrous as a collision. Supposing, however, that it be desired to stop an engine and train of 100 tons weight in 200 yards, it would require, if the original speed was 60 miles an hour, a sustained dead pull of 20 tons, and this pull obtained by mere friction on the rails. Such a result is not approached by any break power hitherto employed. Unrivalled as the English railway system may be for facility and despatch, its superiority in these respects must be regarded as too dearly bought, if at the cost of repeated scenes of havoc such as the past year has witnessed. The question is, Have sufficient precautions yet been adopted for guarding against similar casualties?

In the administration of railways, more especially if high speeds be insisted upon, the following are among the points which imperatively demand attention:—The inadequacy of the interval of time allowed between the trains; the frequency of signals along the line, particularly in those parts where the engine-driver cannot see the road ahead; the efficiency of break power; the communication between guard, passengers, and driver; the best way of insuring a good look out. As to the last point (without which no precaution in other respects can avail), it is evident that a scanty or overworked staff will always be liable to fail at a time when failure is critical. The skill and intelligence, the wages and general treatment, the rest and holidays of the men on whose alert vigilance the working of the whole system depends, are matters which nearly concern the safety of the travelling public.

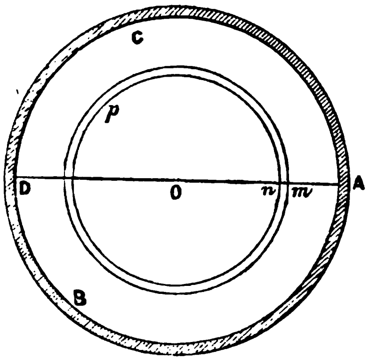
We trust that Mr. Stephenson's letter will receive the attention it demands, and that those who perseveringly vindicate high speeds will not rest satisfied until such precautions are generally adopted as (not for want of warning) have in too many instances been neglected.

CALCULATIONS RESPECTING THE PRESSURE OF STEAM ON CYLINDER COVERS AND OTHER DISKS.

By Oliver Byrne, Civil Engineer.

Writers on the strength of steam boilers and cylinders assert that it requires a pressure of steam equal to the cohesive strength of the cross section of the cylindrical surface to remove the circular head; that is, if ACB, Fig. 1, be a cross section of the cylindrical cover, and that it would require a force of 3,000,000 lbs. to overcome the cohesive strength of this cross section, then it would require 3,000,000 lb. pressure of steam on the circular disk AOCB to remove it, or overcome the cohesive strength of the rim ACB. Now, this is far from the truth, for any pressure applied at the centre, O, is more effective in removing the disk or circle ACB, than if the same pressure were applied at any point m, nearer the rim. In the first place I will prove that one-third of the pressure evenly spread over the circular cover applied at the centre, O, will have the same effect to remove the disk as the whole pressure equally spread over the surface ABC. Put $|\overline{x}$, for the differential of x instead of dx, and take care not to call $|\overline{x}$ the square root of, but the differential of x. Let $OA=r$, $mA=x$, $mn=|\overline{x}$, then $Om=r=x$.

Fig. 1.

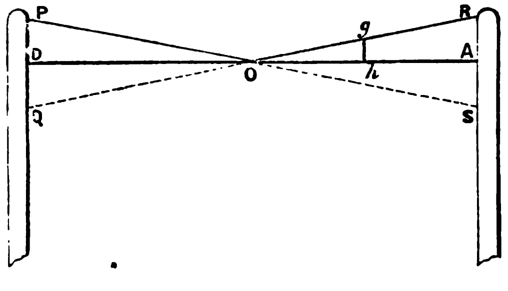


The effective pressure of the particle $|\overline{x}$ at the point $A = x\,|\overline{x}$; then putting as usual $\pi = 3{\cdot}1416$, an arc of 180° to radius 1, the pressure on the elementary space or circle mnp will be represented by $2\pi(r-x)x\,|\overline{x}$, which, when integrated between the limits $x=o$, $x=r$, gives

$$2\pi\int_r^0 (r-x)x\,|\overline{x}=2\pi\frac{r^3}{6}$$

This last expression may be reduced to $\frac{\pi r^2}{3}\times r$, which is one-third the area of the circle ACB multiplied by the radius r. The area πr^2 may represent the whole pressure equally spread over the whole surface; then it is evident that the sum of all the products of all the elementary areas x, and their distances x from the rim ACB, is equal to one-third the whole area of pressure applied at the centre O, multiplied by the radius r.

Fig. 2.



Practical Example.—Let Fig. 1 represent a cylinder head of cast iron 4 feet in diameter; what must be its thickness at the rim ACB to sustain a pressure of 90 lbs. to the square inch? A circle of 48 inches diameter has an area of 1810 square inches, and a circumference of 15 inches, nearly. Consequently, in the well-known formula

$$t=\sqrt{\frac{lw}{sb}}$$

w = pressure at the centre O, equal $\frac{1}{3}$ the pressure on the whole surface, $=\frac{1810\times 90}{3}=54300$ lbs. l=AD=4 feet, b=151 inches, the breadth or circumference of the circle ACB. $s=a$, number determined by experiment on different materials; in cast iron s varies from 850 to 215, t=the thickness. Hence, in the example before us, taking $s=215$, the least value,

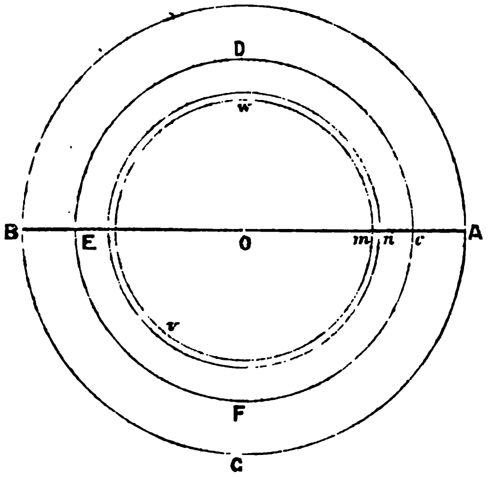
$$t=\sqrt{\frac{54300\times 4}{215\times 151}}=2\cdot 586 \text{ inches.}$$

Since $b=\pi\,(12l)$, and if $3p$ be made to represent the whole pressure on the circular end, then $w=\frac{\pi}{4}\left(12l\right)^2 p$

$$\therefore t=\pm\sqrt{\frac{lw}{sb}}=\pm l\sqrt{\frac{3p}{s}}.$$

Fig. 2 represents a section through O, Fig. 1, AD=4 feet, then AR=PD=2·586 inches. If Oh=hA, then gh=half AR, to sustain the pressure of steam on a circular cover whose diameter is equal twice Oh, consequently, OgR is a straight line. There are two values of t, showing that the conical surface may be either above or below the diameter DA.

Fig. 3.



To find the pressure applied at the centre O, Fig. 3, acting at a distance OA, and equal to a pressure applied equally over the circle CDE; the distance CA from the rim being constant, and the pressure on the annular space CADEF being neglected.

By a variable pressure, the centre O is easily made to vibrate; hence the pressure on the elementary annular space $mnuv$, as in the former case is only considered with respect to the fixed rim AGB. The space $mnuv$ may be supposed to move up and down freely, compared with the resistance to fracture offered at the rim. Fig. 4 illustrates this matter, for let PQ=48 inches; now let PQ be only increased $\frac{1}{10}$th of an inch, the line PMQ becomes 48·1 inches, while the perpendicular MN becomes 1·55 inches, or $15\frac{1}{2}$ times the elongation received by PQ, or $(24)^2+(1\cdot 55)^2=(24\cdot 05)^2$.

To return to the direct investigation, let CA=a; Cn=x; mn= x, the differential of x. The momentum of x will be $(a+x)$ x acting independently at the distance $a+x$ from A. Again let c=OC; then Op=$c-x$, and the circumference of the elementary space $mnuv=2\pi\,(c-x)$, and the sum of all the pressures acting on the elementary space $mnuv$, will be represented by $2\pi\,(c-x)\,(a+x)\ |x$; the integral of which is

$$2\pi\left(acx-\frac{ax^2}{2}+\frac{cx^2}{2}-\frac{x^3}{3}\right);$$

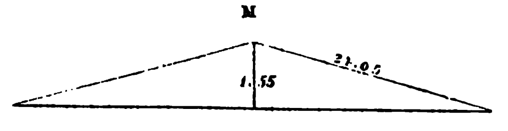
which, when taken between the limits $x=o$ and $x=c$, becomes

$$2\pi\left(\frac{ac^2}{2}+\frac{c^3}{6}\right)=\frac{\pi c^2}{3}\left(c+3a\right);$$

so that one-third of the area of the circle CDEF multiplied by OC, the radius, increased by three times the breadth of the annular space AC, or $(c+3a)$, is equal to the uniform pressure spread over the surface of the circle CDEF acting upon the rim of the outer circle CGB.

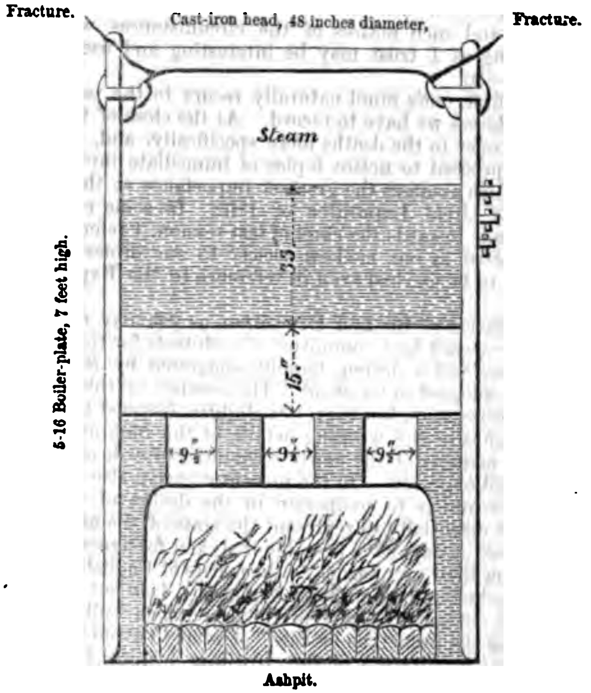
I will conclude with the details of the bursting of a boiler that have lately fallen under my notice. Fig. 5 is the section of a boiler with a cast iron head 48 inches diameter and $1\frac{7}{8}$ inches thick.

Fig. 4.



This boiler belonged to Mr. Wheeler Beers, of Bridgeport, Connecticut, U.S. America, and stood a pressure of from 60 to 70 lbs. on the square inch for about six months, and then burst without much noise and destroyed the building in which it was placed. The head vibrated considerably, and was found whole not many feet from where the boiler stood. The fracture took the direction indicated in the figure, and so even all round that it might be considered the frustum of a cone. The bursting of this boiler led to a lawsuit, and several experiments were tried under my superintendence to determine the proper shape and dimensions for cast iron covers, and the effects of vibrations. The investigations here established I found to agree very well with my experiments. In pressing or forcing out a circular head by a pressure in the centre, half the circumference might be taken for the breadth of a beam fixed at both ends and loaded in the middle, the thickness of the metal the depth, and the diameter the distance between the supports; but I used the whole circumference and lessened the value of s accordingly.

Fig. 5.


Fracture.
Cast-iron head, 48 inches diameter.
Fracture.
Steam
35"
15"
9½"
9½"
9½"
5-16 Boiler-plate, 7 feet high.
Ashpit.

Proposed Music Hall at South Kensington.—There is in course of formation a company to be called the "International Hall Association." The capital is to be £20,000, in shares of £5 each. The object of the Association is to erect a temporary hall, immediately adjoining the International Exhibition building for 1862, for a series of concerts on a grand scale, under the direction of Mr. Alfred Mellon. It is proposed that the hall shall cover an area of 22,500 feet, be circular in form, and be erected at a cost of about £15,000, including fittings and rent of site for the year. The building is proposed to accommodate an audience, exclusive of the orchestra, of ten thousand persons. The orchestra will be capable of holding from a thousand to twelve hundred performers, and the building will include refreshment and cloak-rooms, &c. The offices of the association are at 442, Oxford-street, where a plan of the intended building may be seen.

OPENING ADDRESS TO THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Session 1861-62.

By William Tite, M.P., President.

On a similar occasion to the present, two years ago, you did me the honour to invite me to read an Opening Address on the occasion of the inauguration of these apartments as our resting-place. On that occasion I endeavoured to bring before you a general review of the state of architecture at that time in Europe, and of its probable future prospects. The interval is not long, but it is marked with important incidents, whether relating to ourselves or the world of art in general. We have lost a noble and beneficent patron and president, and, on the other hand, some of the incidents and considerations which have occurred relating to art in general, and architecture in particular, are most important. These considerations induce me to believe that, in my new character as President, you will allow me this opportunity of suggesting to you such views as occur to me having reference to the past, and such notices of the circumstances which are now occurring as I trust may be interesting and useful to us in our profession.

As to the first, one's mind naturally recurs to the personal or professional losses we have to record. At the close of this paper I propose to refer to the deaths more specifically, and, therefore, at present I proceed to notice topics of immediate interest; and first, that which assumes the greatest importance at the present moment—the Great Exposition of 1862. In some concluding remarks I made towards the close of last session, I referred to the position allotted in our modern society to our profession, and this appears to be marked even in reference to the Exposition of 1862.

On the occasion of the first Exposition, as you may remember, the design proposed by a committee of architects for the building was set aside, and a design, happily suggested by Sir Joseph Paxton, was adopted in its stead. The services of the members of this Institute were, however, but slightly resorted to, and the superintendence of the working details of the building was intrusted to a member of the newly recognised branch of our profession, a civil engineer. On the present occasion also the claims of British architects to co-operate in the design of a building which ought essentially to represent the state of the art amongst us at the present day, have been ignored; and foreigners are thus likely to form their opinions as to the merits of English architects from the production of a military engineer. I do not propose to criticise the designs of either of the Exposition buildings, notwithstanding the numerous lessons "of what to avoid" they both furnish. But in the name of this Institute I think it my duty to protest against the official exclusion of architects from the councils of those who assume to represent the taste of the nation in the various branches of art.

Unfortunately, it would seem that the public in general participates in the species of disfavour which this exclusion of recognised architects from the councils of the past and future Expositions may be considered to indicate; and the cheers with which vulgar, unreasoning abuse of our profession is almost always received ought to inspire us with serious anxiety. I believe from the bottom of my heart that the accusations brought against us as a body are essentially false; that architects generally are honourable, conscientious men—hard students, earnest thinkers, and bringing to bear upon their professional duties such an amount of varied information, practised skill, educated talent, and high-minded integrity, as would in any other profession insure a far greater share of wealth and distinction than we usually attain. Feeling very strongly as I do on this question, it is to me the more painful to observe the existence of an opinion precisely opposed to my own in those who might be supposed to have known us intimately; and when such men as the present Under Secretary of State for Foreign Affairs did not hesitate to state in Parliament on the debate on the British Museum, that he advocated the plan proposed by Mr. Oldfield, because it was not prepared by a professional architect, and that the great success of the great reading-room was due to the fact that in that case "the trustees were not trammelled by an architect;" and further that, in a crowded House, these opinions met with considerable applause; again, looking at Mr. Layard's remarks in the debate on the Foreign Office, in which we are spoken of most disparagingly;—and this being so, I am forced to ask myself whether these things can be true? They say that "there can be no smoke without fire," and it behoves us therefore, whatever fire may exist to cause the smoke now obscuring our fame, to trample it out.

Again, I cannot but regret to observe the almost unanimous recognition of the distinction lately established between the pursuits of engineering and of architecture; because I am convinced that both of them would gain by being studied and practised simultaneously. In former time, and indeed until the establishment of the "Corps Royal des Ingénieurs des Ponts et Chaussées," in the middle of the last century, no such distinction was admitted. Sir C. Wren and Mansard were both architects and engineers; Perronet called himself "Architect du Roi;" Robert Mylne called himself architect and engineer; Telford began his public career by building a church. It was the development of the canal system which first led to the separation of engineers and architects among ourselves; and to some extent this may be explained, for the pursuits of the architect lead his studies rather towards the conditions of statical, than of dynamical forces, whilst the canal and dock engineer has to deal very frequently with the latter. But in the execution of roads, railways, and such works, there are no conditions which ought to be beyond the sphere of an architect's knowledge; and I very strongly suspect that if architects had been more frequently employed on railway works, our marvellous network of rails would have been constructed at less cost than it actually has involved; and that we should not have heard of so many accidents from "striking centres too soon," or from "the rain washing the mortar out of the arches." It is true that the construction of railways does not afford many opportunities for the exercise of the artistic faculty, the noblest one the architect is called upon to employ. It is a kind of work which requires more of science than of art. But our profession ought above all others to present the union of the art and science; and he is a bad architect, in the true sense of the word, who is incapable of becoming "the best workman" in any of the branches of what I may be allowed to call statical construction. I dwell upon this subject, because it seems to me that much of the favour with which civil and military engineers are now regarded, and their employment to the exclusion of architects in the cases of the Exposition buildings, may be explained by the mistaken opinions which prevail with respect to the pursuits and abilities of the latter. Not to travel beyond the names I have before noticed, I may be allowed to observe that the engineering works of Mr. Hosking upon the West London Railway may well compare with the architectural achievements of Sir William Cubitt in the first Crystal Palace. Be this as it may, it behoves us at least to render ourselves capable of discharging the ordinary duties of engineers and architects. Hydraulic engineering may require a different mental training, and a course of study of a different character, to that required for building in the open air; but it is absurd to suppose that the man who can build a church could not build a bridge or a viaduct, or that he should be unable to conduct great earthworks or tunnels.

Before leaving the subject of the Exposition buildings, I cannot refrain from saying that the design given in the *Builder* of the Florence Exposition, strikes me as containing far more artistic merit, and as presenting a more satisfactory architectural character, than the published design of the proposed building at South Kensington; no doubt because in this instance, as in the instance of the construction of the Palais de l'Industrie of Paris, educated architects were consulted. Passing over this part of the subject, however, I am sure that all my hearers will agree with me in the expression of the deep sympathy excited by the first Italian Exposition. These industrial gatherings have assumed of late years a deeper moral significance than could possibly have entered into the philosophy of their founders, and they have become the occasions for eliciting the expression of the most recondite forms of national thought and feeling. An Italian Exposition, held in the city of Giotto, Dante, Michael Angelo, and the Medici, becomes therefore the matter for serious reflection to those who wish that in truth Italy should cease to be "a geographical expression," and we—whether admirers of the Broletti and of the town halls of the Mediæval republics, or of the palazzi, cassine, or churches of the Risorgimento—must turn an anxious gaze on the first steps of the noble Italian race in the political *risorgimento* which is at present taking place in that land so long cursed with what all considered "the fatal gift of beauty." Our sympathies may be of small import to the Italians in the struggle they have still to go through before they can establish a strong nationality such as "the advanced civilisation" of the age requires; but

I am sure that an assembly of architects will unanimously join in the expression of goodwill towards the Italian cause. May the Exposition of Florence prove the harbinger of the full glory of bright days for Italy!

The Artistic Congress of Antwerp, too, fussy and unpractical though it may seem to have been, contains the germs of an organisation which may, perhaps, produce for art consequences as important as those produced by our "Association for the Advancement of Science" in its particular sphere. In these days of architectural and artistic eclecticism, it would manifestly be advantageous for the student to be able to study with his own eyes every local manifestation of æsthetical feeling; for the subtle influences of climate, political and municipal organisation can never be appreciated unless we have the means of watching their daily operation; and few learned treatises on the Art History of Nations enable us to appreciate the nature and extent of the action and reaction of building or of plastic materials on the visible expression of art. The amount of good to be effected by these gatherings must depend on the manner in which they are conducted. As an isolated experiment, the Antwerp Congress was very successful. It were a marvellous pity that it should remain an isolated experiment.

Whilst thus attending to foreign operations, it may be as well to continue our attempts to derive lessons from them before turning to more decidedly local considerations, and I would therefore strive to point the moral of some other tales to be read in the proceedings of our immediate neighbours. Thus, all travellers who return from Paris are, upon a superficial view of what is taking place there—and, it must be added, in almost every important town of France—disposed to find fault with the comparatively slow rate at which improvements are effected in London. Within ten years Paris has been, in fact, remodelled throughout; and broad streets, open squares, and fine houses, have replaced the ancient narrow, tortuous assemblages of dens of filth and impurity. It is to be feared, however, that the real sanitary improvement of Paris has gained little by these changes; and, indeed, so long as the water supply and the sewerage of that town are conducted on the present systems, little effect can be produced on that infallible test of the value of the sanitary arrangements of a town—*the average death rate.* I advise those who believe that "they manage all these things better in France than we do here," to visit the intake of the Challiot Waterworks, or to ponder over the charge he will have to pay, even in a private lodging, for that necessity of an Englishman's life, the daily hip-bath. Nor is this all; for they who knew much of Paris life in former times must be painfully convinced that the embellishments of the town have resolved themselves into heavy charges on its inhabitants, whilst the utility of many of the costly works now in hand must seem more than questionable. House rents have risen to fabulous heights in Paris; the poor are driven from their old haunts, and no refuge is provided for them; whilst, unfortunately, the sanitary defects of the old houses are servilely reproduced in the new ones. But, however painfully these defects may strike us on second and calmer thoughts, it cannot be denied that there is something fairy-like in the rapidity and the brilliancy of the change actually produced; and we naturally inquire by what financial agency it has been produced. My friend, Mr. G. R. Burnell, has made some inquiries into this matter, which I hope that he will be able to communicate to you in the course of the session; but in the meantime I may say that the impression I have derived from what he has told me is, that the improvements of Paris have been effected upon principles of political economy, and by dint of an abuse of public credit which would never be tolerated in this country. We hold that local improvements should be paid for by local contributions, and that building speculations should not be assisted by financial corporations, patronised, if not directly managed, by the government. The opposite principles prevail amongst our neighbours, and, sooner or later, it is to be feared that they must produce, even if they are not now producing, sad confusion in the finances of the state.

One matter of detail may be worth especial notice from us—viz. the conditions under which the municipality is now able to obtain land for the purpose of effecting any new works declared to be *d'utilité publique.* Until 1852 the municipality, under the old law of expropriation, could only take compulsorily the land absolutely required for the establishment of the streets, and the proprietors of the land partially effected were entitled to retain the remainder of their property, with all the increased value conferred by the new frontages. At the very close of the dictatorial power assumed by the Emperor in 1851, a decree, "having force of law," was issued however, by which municipal bodies, charged with the execution of works of public utility, were empowered to take an additional width of land beyond the lines of the intended streets, sufficient to allow the construction of good houses. The effect of this law has been that the municipalities of France have lately been enabled to sell the frontages on the new leading thoroughfares they open at advantageous terms, and thus, at the expense of the landed proprietors disturbed, materially to diminish the cost of the works. If the latter had been discussed by a really representative body, there could be little reason to regard the advantages thus given with jealousy; but when the works to be executed are simply prescribed by the central government, it is to be feared that great abuses may arise from the interference with the rights of private property it may be made to cover.

The success of the artesian well of Passy is a subject of great interest to all who are called upon to deal with the supply of water to detached mansions, or even to small towns; and to us Englishmen it is the more interesting on account of the recent failures to establish similar wells at Highgate, Harwich, as well as at Calais and at Ostend. The boring at Passy, after passing through the same beds as had previously been traversed at Grenelle, reached the water-bearing stratum at a depth of 1797 ft. 6 in. from the surface, and the water rose to a height of 13 ft. from the ground. The lower diameter of the well is about 2 ft. 4 in.; and the quantity of water it delivers has, after some oscillations, settled to about 3,791,000 gallons per twenty-four hours. At present the sand and clay brought up by the water are in such proportions that the water is not fit for use, a fact which was also observed at Grenelle during the first year after the completion of the boring. The water rises to about 82 degrees Fahrenheit. One effect of this well has been to diminish notably the yield of the Grenelle well, and it must, therefore, for some time to come remain an open question as to whether or not the water-bearing stratum under Paris will be able permanently to maintain these two springs. The discussion of the failure of the attempts to obtain water in a similar manner to which I have above referred would extend to so great a length that I must pass it over slightly at present, but the great lesson to be learned from it seems to me to be, that at the present day our acquaintance with the laws of geology is only sufficiently advanced to enable us to say with certainty what we shall *not* find beneath the surface in districts which have not been exposed to violent subterranean disturbances; they are utterly incapable of telling us what we *shall* find. At London, Harwich, Calais, and Ostend, the lowest member of the subterranean formations, from which the wells of Passy and Grenelle derive their supply, is entirely wanting.

A very warm and rather an acrimonious discussion is now being waged amongst the chemists and experimental observers on the laws of metallurgy with respect to the differences between iron and steel; and the names of Binks, Mushet, Bessemer, Fremy, and Caron, add weight and authority to the various opinions propounded on this very obscure subject "*Non nostrum inter eos tantas componere lites*," and Messrs. Fremy and Caron may well be left to settle the precise amount of influence exercised by the nitrogen, cyanogen, and carbon present during the cementation of steel upon the resulting product. The influence these researches may exercise upon the building arts may however be very great; and the production of steel by the new methods suggested by an improvement in the theory of the production of steel may possibly place within our reach a material possessed of far more valuable elastic properties than either cast or wrought iron. We must therefore follow with interest the steps of this inquiry and hold ourselves ready to adopt any improvement it may place at our command. I would make the same remark with respect to the recent applications of electricity to the ordinary purposes of life; and I would urge the members of our Institution to avail themselves wherever it is possible of the great domestic conveniences that wonderful agent is able to supply. We in England are behind our French neighbours in this respect.

In domestic matters the most important lesson to be derived from the events of the last twelve months is, perhaps, the one connected with the terrible fires in the river-side warehouses. In a city so essentially commercial as London, it must always be desirable to interfere as little as possible with the arrangements, 1846 M. Wertheim published a memoir, written in conjunction with M. Chevandier, 'Upon the Mechanical Properties of Wood,' which, unfortunately, has not yet been translated into English; and in a memoir 'Upon the Double Refraction produced in Isotropous Bodies,' M. Wertheim discussed the results obtained by Mr. Hodgkinson from his experiments upon the elastic conditions of cast and wrought iron, suggesting for the purpose of observing the gradual effects of compression of solid bodies the elegant chromatic dynamometer. This memoir will be found in the 'Annales de Chimie et de Physique.'

The name and works of Vicat are of course known to all who have followed the history of modern science. Engaged in early life in the actual practice of his duties as engineer of the Ponts et Chaussées, he constructed some of the roads leading to Genoa on the banks of the Isle river, in the Perigueux; and in 1813 he was appointed engineer to the Bridge of Souillac, over the Dordonne, and it was in the course of the preliminary studies for this work that he was led to the discoveries which have so materially advanced the building arts and immortalised his name. At Souillac Vicat introduced the system of founding the piers of bridges on masses of concrete, sunk under water within close piled enclosures, or "caisses sans fonds," and to secure the success of the system it was necessary that he should use a lime which should be capable of setting under water. The chemical theory of limes and cements was at that period but very little understood, though the researches of Smeaton, Huggins, Guyton de Morveau, Bergmann, and de Saussure, and the introduction by Wyatt of the Roman cement, had placed at the disposal of enquirers many of the elements of its solution. About the year 1817, Vicat communicated to the Academie des Sciences the results of his analytical and synthetical experiments upon the composition of limes of various qualities; and he then propounded the theory which subsequent inquiries have confirmed and developed, to the effect that the hardening of mortars depended on the combination which takes place in them between the lime and the silicate of alumina they contained. Vicat published in some separate *brochures* the results of his subsequent experiments, and in the 'Annales des Ponts et Chaussées,' he has also published some important memoirs on the strains to which suspension bridges are exposed, on the resistance of iron wire ropes, on the compression of solid bodies, and on the statistics of the lime-producing formations of France. He co-operated with M. St. Leger in the introduction of the manufacture of the artificial hydraulic limes, and indeed he must be considered to have led the way to all the modern improvements in that important branch of the building arts. M. Vicat was fortunate enough to witness the universal recognition of the truth and of the practical importance of his discoveries, which, with the true spirit of a philosopher, he had at once unreservedly placed at the service of the public. He received honours from every government which in turn has ruled in France during his long and useful career, and in 1845 the legislature of his country unanimously voted him a pension of 6000 francs a year, on the strength of a report presented by MM. Arago and Thenard. When in 1853 Vicat resigned his post on account of his advanced age, he was named by a special decree of the Emperor, Honorary Inspector-General of the Ponts et Chaussées, a dignity created expressly to honour this earnest and disinterested student. Vicat's works have been translated into almost every language of Europe; into our own, by Captain E. H. Smith. Vicat died on 10th April, 1861, aged 75 years.

In the course of this year also, the ranks of science have lost M. Berthier, the distinguished author of the 'Traite des Analyses par la Voie sèche,' in the course of which will be found some chapters bearing upon our profession. Berthier devoted, in fact, much attention to the examination of Vicat's discoveries, and has discussed the principles on which they are founded; he also paid attention to the analytical inquiries into the nature of other building materials, and of the metals used in construction. Berthier died 24th August, 1861.

We have to regret also the loss of Sir William Pasley, whose name has been so intimately connected with the diffusal in our country of the inventions and theories of Vicat. Sir William was born in 1781, and in 1797 he entered the army as second-lieutenant of artillery, but in the next year he exchanged into the Royal Engineers. He served at the defence of Gaeta, in 1806; at the Battle of Maida; at the Seige of Copenhagen; as Aide-de-camp to Sir J. Moore, in 1808-1809. In the Walcheren Expedition, Sir William, then Captain Pasley, was wounded twice; he then served in the Peninsular War until 1812; and in 1813 he was appointed Director of the Royal Engineers Establishment at Chatham, a post he retained until his nomination as major-general in 1841. The connection of General Pasley with our profession is to be sought principally in the various papers inserted by him in the Corps Papers of the Royal Engineers; in his 'Observations on Limes and Calcareous Cements,' 8vo., London, 1838; in the interesting operations for the removal of the wreck of the Royal George, and in blasting the Round Down Cliff, near Dover; indirectly, his duties as Inspector of Railways also brought General Pasley in contact with some of the members of our profession. Perhaps I may be allowed especially to call attention to the part which Sir William bore in the introduction of the artificial, over-calcined cements, known at the present day by the name of the Portland cements. In this instance, Sir William worked in connection with the late Mr. Frost, and those gentlemen seem only to have missed the discovery of the influence of excessive calcination upon the action of the slow-setting cements, in their curious and valuable researches. Sir William Pasley died on the 19th April, 1861.

Mr. Eaton Hodgkinson was one of the students of the abstruser branches of science connected with our profession, whose labours will long continue to influence its practical details, and he may also be cited as one of those who achieved distinction by his "self-help," even while following studies of the most recondite order. Without any adventitious aids from family connection or of wealth, Mr. Hodgkinson had succeeded in making himself sufficiently known for his acquaintance with the application of the higher branches of mathematics to the physical sciences (especially by the publication of a paper in the Memoirs of the Manchester Society for 1822), to be employed by the engineers of that very practical town to conduct some experiments on the strength of cast-iron, and on the best form of section to be adopted for girders. Previously to the publication of Mr. Hodgkinson's inquiries, the rules laid down by Tredgold on these subjects had been universally received by practical men; and he reasoned upon the supposition that cast-iron, like other solid bodies, resisted equally the force of compression exercised upon the top or upon the bottom, when loaded as a beam. Tredgold therefore inferred that the best form of section would be one resembling the letter I, with equal flanges at the top and at the bottom. Hodgkinson, however, discovered that cast-iron presented some anomalous conditions of elasticity, and that especially it resisted efforts of compression with an energy which was nearly six times as great as the energy with which it resisted efforts of exension; he was thus led to recommend a form of cross section for girders in which the upper and lower flanges were made to present sectional areas corresponding with the efforts of compression and of extension they would respectively have to resist. The late George Stephenson was one of the first engineers to adopt this form of girder for the bridge on the Liverpool and Manchester Railway, over Water-street, Manchester, erected in 1830; since then it has been adopted universally, though for my own part I confess that the unequal rates of cooling in the top and bottom flanges of Mr. Hodgkinson's form of girders seems to me to involve a very serious practical danger, on the score of the soundness of the casting in which the areas of the flanges are so markedly unequal.

Mr. Hodgkinson then devoted his time and attention to a series of investigations into the general laws of the elasticity of rigid bodies, and of the strength of pillars of cast-iron and of other materials. His methods of observation were far from being as elegant or refined as those adopted by M. Wertheim, but they have been made more practically useful, and the empirical formulæ deduced from them still regulate the practice of engineers and architects. Mr. Hodgkinson's results were published in the Transactions of the Royal Society in 1840, and they were judged worthy to secure their author the Royal Gold medal, and his nomination as a member of that learned body. In 1845 Mr. Hodgkinson was engaged by Mr. Robert Stephenson, in conjunction with Mr. Fairbairn, in the experiments it was considered necessary to make previously to constructing the tubes of the Conway, and of the Britannia bridges; and it is to the results so obtained that we are indebted for the wonderful change introduced in the building arts by the application of wrought-iron plain and boxed girders. The most important facts thus elicited by Mr. Hodgkinson were communicated by him to the "Commissioners to inquire into the application of iron to railway structures" named in 1847, in consequence of the failure of the Dee Bridge at Chesminor details—permitted the re-use of the chancel. Before the alterations, besides the ordinary dilapidations and whitewash, the interior presented a mass of obstructions. One huge gallery under the chancel arch so overhung the ancient pulpit (a remarkably rich specimen of stone panelling) that no one could stand comfortably in it. The chancel was almost concealed from the nave, and, except for the sacrament, was never in use; while other galleries rendered the transepts equally unavailable. The roofs of nave and transepts were hidden by a flat ceiling, and it was difficult for any but a practised eye to recognise, beneath all these unseemly encumbrances, the true features of what now appears to be one of the most beautiful examples of the best period of Gothic architecture. In the year 1854 the church was placed in the hands of Mr. G. G. Scott, and in 1858 the restoration of the nave was accomplished, and to this has now been added that of the chancel.

Several styles are observable in different portions of the edifice, but the prevalent one is that of the fourteenth century. We may, however, mention that the west door is a beautiful relic of an earlier church. The tower is of peculiar merit, being square up to the roof ridge of the nave, and octagonal above it, with a stair turret carried up one side, and boldly projecting above the pinnacles with which the angles of the octagon are crowned. The chancel has magnificent stalls of excellent workmanship, and its stone vaulting has some curious bosses representing the closing scenes of our Lord's life. The nave and transepts are now uniformly seated with substantial open benches, the whole of the stonework has been repaired, and the warm rich colour of the red sandstone of which the chancel is built is once more visible. The northern portion of the north transept, formerly a chantry, and opening into the transept by a fine arch, is now appropriated for the organ, which has been improved and enlarged by Messrs. Hill and Son. In the chancel encaustic tiles have been laid down, chiefly copied from the original patterns, of which some fragments remained. The noble seven-light east window has been filled with stained glass, and two elaborate niches, on either side, have been carefully restored, as also the old aumbry and sedilia. A reredos is also in contemplation, to be the gift of Lord Crewe, the patron of the living, at whose expense this restoration of the chancel has been effected.

EXPERIMENTS ON THE GAUGING OF WATER BY TRIANGULAR NOTCHES.*

By J. Thomson, A.M.,
Professor of Civil Engineering, Queen's College, Belfast.

In 1858 I presented to the Association an interim report on the new method which I had proposed for the gauging of flowing water by triangular (or V-shaped) notches, in vertical plates instead of the rectagular notches with level bottom and upright sides in ordinary use.† I there pointed out that the ordinary rectangular notches, although for many purposes suitable and convenient, are but ill-adapted for the measurement of very variable quantities of water, such as commonly occur to the engineer to be gauged in rivers and streams; because if the rectangular notch be made wide enough to allow the water through in flood times, it must be so wide that for long periods, in moderately dry weather, the water flows so shallow over its crest that its indications cannot be relied on. I showed that this objection would be removed by the employment of triangular notches, because in them, when the quantity flowing is small, the flow is confined to a narrow and shallow space, admiting of accurate measurement; and as the quantity flowing increases, the width and depth of the space occupied in the notch increase both in the same ratio, and the space remains of the same form as before, though increased in magnitude. I proposed that in cases in which it might not be convenient to form a deep pool of quiet water at the upstream side of the weir-board, the bottom of the channel of approach, when the triangular notch is used, may be formed as a level floor, starting exactly from the vertex of the notch, and extending both up-stream and laterally, so far as that the water entering on it at all its margin may be practically considered as still water, of which the height of the surface above the vertex of the notch may be measured in order to determine the quantity flowing.

I indicated theoretic considerations which led to the anticipation that in the triangular notch, both with and without the floor, the quantity flowing would be proportional or very nearly so to the $\frac{5}{2}$ power of the height of the still-water surface above the vertex of the notch. As the result of moderately accurate experiments which I had at that time been able to make on the flow in a right-angled notch without floor, I gave the formula $Q = 0{\cdot}317\ H^{\frac{5}{2}}$, where Q is the quantity of water in cubic feet per minute, and H the head of water, as measured vertically, in inches, from the still-water level of the pool down to the vertex of the notch. This formula I submitted at that time temporarily, as being accurate enough for use for many ordinary practical purposes, for the measurement of water by notches similar to the one experimented on, and for quantities limited to nearly the same range as those in the experiments (from about 2 to 10 cubic feet per minute), but as being subject to amendment by future experiments, which might be of greater accuracy, and might extend over a wider range of quantities of water Having been requested by the general committee of the association to continue my experiments on this subject with a grant placed at my disposal for the purpose, I have, in the course of last summer and present summer, devoted much time to the carrying out of more extended and more accurate experiments. The results which I have obtained are highly satisfactory. I am confident of their being accurate. I find them to be in close accordance with the law which had been indicated by theoretical considerations; and I am satisfied that the new system of gauging, now by these experiments made completely ready for general application, will prove to be of great practical utility, and will afford for a large class of cases important advantages over the ordinary methods,—for such cases especially as the very varying flows of rivers and streams.

The experiments were made in the open air, in a field adjacent to a corn mill, in Carr's Glen, near Belfast. The water supply was obtained from the course leading to the water-wheel of the mill, and means were arranged to allow of a regulated supply, variable at pleasure, being drawn from that course to flow into a pond, in one side of which the weir-board with the experimental notch was inserted. The inflowing stream was so screened from the part of the pond next the gauge notch as to prevent any sensible agitation being propagated from it to the notch, or to the place where the water level was measured. For measuring the water level a vertical slide wand was used, with the bottom end cut to the form of a hook, the point of which was a small level surface of about $\frac{1}{8}$ inch square. This point of the hook, by being brought up to the surface of the water from below, gave a very accurate means for determining the water level, or its rise or fall, which could be read off by an index-mark near the top of the wand, sliding in contact with the edge of a scale of inches on the fixed framing which carries the wand.

By other experiments a sharp pointed hook, like a fishing-hook has sometimes, especially of late, been used for the same purpose, and such a hook affords very accurate indications. The result of my experience however leads me to incline to prefer something larger than the sharp-pointed hook, and capable of producing an effect on the water surface more easily seen than that of a sharp-pointed hook; and on the whole I would recommend a level line, like a knife-edge, which might be from one-eighth to half an inch long, in preference either to a blunt point with level top, or a sharp point. The blunt point which I used was so small, however, as to suit very perfectly. If the point be too large it holds the water up too much on its top, as the water in the pond descends, and makes too deep a pit in the surface as the water ascends and begins to flow over it. The knife-edge would be free from this kind of action, and would I conceive serve every purpose perfectly, except when the water has a velocity of flow past the hook, and in that case, perhaps, the sharp point, like that of a fishing-hook, might be best.

To afford the means for keeping the water surface during an experiment exactly at a constant level, as indicated by the point of the wooden hook, a small outlet waste sluice was fitted in the weir board. The quantity of water admitted to the pond was always adjusted so as to be slightly in excess of that required to maintain the water level in the pond slightly above the height at which the hook was fixed for that experiment. Then a person lying down, so as to get a close view of the contact of the water surface with the point of the hook, worked this little waste or regulating sluice, so as to maintain the water level constantly coincident with the point of the hook.

The water issuing from the experimental notch was caught in a ing of the falling vein of water to the outside of the notch, which would evidently produce a much greater proportionate effect on the very small flows than on great flows. The special purpose for which the wide notches have been proposed is to serve for the measurement of wide rivers or streams, in cases in which it would be inconvenient or impracticable to dam them up deep enough to effect their flow through a right-angled notch. In such cases I would now further propose that, instead of a single wide notch, two, three, or more right-angled notches might be formed side by side in the same weir board, with their vertices at the same level. In cases in which this method may be selected, the persons using it, or making comparisons of gaugings obtained by it, will have the satisfaction of being concerned with only a single standard form of gauge notch throughout the investigation in which they may be engaged.

---

* Read before the British Association at Manchester.

† See *C. E. & A. Journal*, vol. xxi. p. 369.

By comparison of the formulas given above for the flows through the two notches experimented on, of which one is twice as wide for a given depth as the other, it will be seen that in the formula for the wider notch the co-efficient ·636 is rather more than double the co-efficient ·305 in the other. This indicates that as the width of a notch considered as variable increases from that of a right-angled notch upwards, the quantity of water flowing increases somewhat more rapidly than the width of a notch for a given depth. Now, it is to be observed that the contraction of the stream issuing from an orifice open above in a vertical plate is of two distinct kinds at different parts round the surface of the vein. One of these kinds is the contraction at the places where the water shoots off from the edges of the plate. The curved surface of the fluid leaving the plate is necessarily tangential with the surface of the plate along which the water has been flowing, as an infinite force would be required to divert any moving particle suddenly out of its previous course.* The other kind of contraction in orifices open above consists in the sinking of the upper surface, which begins gradually within the pond or reservoir, and continues after the water has passed the orifice. These two contractions come into play in very different degrees, according as the notch (whether triangular, rectangular, or with curved edges) is made deep and narrow, or wide and shallow. From considerations of the kind here briefly touched upon, I would not be disposed to expect theoretically that the co-efficient C for the formula for V-shaped notches should be at all truly proportional to the horizontal width of the orifice for a given depth; and the experimental results last referred to are in accordance with this supposition. I would, however, think that from the experimental determination now arrived at, of the co-efficient for a notch so wide as four times its depth, we might very safely, or without danger of falling into an important error, pass on to notches wider in any degree, by simply increasing the co-efficient in the same ratio as the width of the notch for a given depth is increased.

THE PROFESSORSHIP OF THE ARTS OF CONSTRUCTION AT KING'S COLLEGE, LONDON.

The vacancy created by the death of Prof. Hosking, who had for some years occupied a professional chair at King's College, under the title of Professor of the Arts of Construction, has been filled by the appointment of Mr. Robert Kerr as his successor.

The appointment is unquestionably a happy one, and those who know Mr. Kerr's extensive acquaintance with his profession in its various branches, and his ready and fluent power of expressing his ideas, will readily believe that the new professor will be speedily recognised as one of the ornaments of the College.

We trust that this course of lectures will become in the hands of Prof. Kerr an important agency in promoting that movement in favour of a more complete system and a higher standard of professional education for architectural students, which the new examinations now being inaugurated by the Royal Institute of British Architects are intended to promote. With that movement Prof. Kerr has been, and is, thoroughly identified; and we congratulate him on the distinction which has so opportunely afforded him an occasion of practically contributing to the education of the rising generation of architects and engineers.

We would add that this appointment ought to render these classes more generally attended by architectural students than heretofore. For the most part, the attendance upon them has been confined to students of the College who were destined for the engineering profession. They will now probably be also frequented, as in the case with the admirable classes at London University College, conducted by Prof. Donaldson, by young men who are preparing for the architectural profession, and who, in many cases, are not students in other classes.

PROPOSED EXAMINATIONS FOR ARCHITECTURAL STUDENTS.

The scheme introduced by the Royal Institute of British Architects for voluntary architectural examinations has now been advanced another stage. As already stated in this *Journal*, the principles that a voluntary examination in architecture is desirable, and that the Institute would proceed to establish such an examination, were voted early in the last session, and a scheme was consequently prepared by a committee, and subsequently submitted to the various provincial societies, and to the Architectural Association, for their criticisms and suggestions. Such of the suggestions as seemed worthy of adoption were embodied, and the whole plan was laid before a special general meeting of the Institute held on the 11th ult.

At this meeting the report of the committee embodying the scheme thus elaborated was adopted, and a small sub-committee is now sitting, whose duty is confined to examining and regulating all the details, editing the list of books, and making such other preparations as may be necessary preliminary to the announcement of the whole to the public. As soon as the final report of this sub-committee is sent in and adopted, our readers will have the benefit of it, and we shall then be in a position to announce the date fixed for the first examination. It is, however, generally understood that, with a view to afford students time for preparation, no examination will take place till some considerable time after the publication of the definite regulations and curriculums.

THE NATIONAL DEFENCES.

We have already (*ante* page 172) submitted to our readers the paper on 'The National Defences,' read by Mr. Bidder, jun. at the Institution of Civil Engineers. An excerpt, comprising both the paper and the discussion upon it, has just been issued by the Institution.

It is matter of satisfaction that a subject of vital importance to the nation, and involving many yet undetermined scientific questions, should have been so frankly and fully debated by the members of the institution, in common with gentlemen representing both branches of her Majesty's service. The rapid transformation or development which marks the present phase of warlike science seems to stimulate a continual sort of competition between the appliances of attack and defence. In addition to strategic knowledge, to which, of course, civilians do not pretend, a special acquaintance with the materials and principles of construction that enter into the latest contrivances of warfare is essential; and none are better qualified to deal with this branch of the question than our civil engineers. We therefore think that the Institution have rendered an important public service in taking up the matter as they have done; and we trust they will not allow it to drop.

Two points appear to have come out with sufficient distinctness in the progress of discussion. The first, that the security of these islands must always essentially depend on a home fleet strong enough to command the Channel. The other, that the fortification, at least, of the naval arsenals is a matter of the highest moment. Artillery, as entering equally into the naval and military defences, becomes thus invested with a double interest. We purpose for the present chiefly to consider those parts of the discussion which bear upon this much canvassed branch of the subject. Mr. G. P. Bidder (the President), in opening the discussion, made the following very pertinent remarks as to the two systems of artillery that at present divide the attention of the public:—

"There was another question upon which the paper had not touched, but which ought not to be overlooked in this discussion;—it was, what

---

* This condition appears not to have been generally noticed by experimenters and writers on hydrodynamics. Even MM. Poncelet and Lesbros, in their delineations of the forms of veins of water issuing from orifices in these plates, after elaborate measurements of those forms, represent the surface of the fluid as making a sharp angle with the plate in leaving its edge.

Before proceeding to describe this fuze he would offer one or two observations on the difference of the conditions required in a percussion fuze for sea-service and for land-service. In both forms it was necessary that the fuze should be so constructed as to resist explosion under the greatest amount of violence to which it might chance to be exposed in transport or in handling; but, at the same time, the construction must be such that the act of firing the shell from the gun should have the effect of putting the fuze, as it were, from half cock to full cock, and thus giving it a sensibility which it did not previously possess. There was, however, this important difference in the two cases. In the land-service fuze the sensibility thus acquired could not be too great. The shell ought to explode, if it did but strike a man's hat; but in the sea-service fuze the sensibility must be limited, because a considerable portion of the shells would ricochet from the water, and if they were to explode from that concussion, the chance of their subsequently striking a ship would be lost.

Another important object in the sea-service fuze was to attain the greatest possible rapidity of action, so that the explosion might take place either in the act of passing through the timber, or instantly on entering the ship. Sir Howard Douglas had objected to the use of percussion shells, upon the ground that they passed the fighting side of a ship before they exploded, and wasted their effects upon the opposite side, where the men were not engaged. Quickness was, therefore, a most important consideration; and when he stated that the time which a shell occupied in passing through the side of a ship was only about the 400th part of a second, and that in that minute interval of time all the movements in the fuze must take place—that the flame from the detonator must travel into the shell, and that the combustion of the powder must be sufficiently effected to burst the shell—it would be seen how necessary it was to reduce the times for those processes to the smallest possible limit.

He then proceeded to describe the sea-service fuze, which he stated he had designed with a view to the attainment of these objects, and which he had termed the 'pillar fuze.' Specimens of the fuze were exhibited, and sections of it were shown by the drawings on the wall.

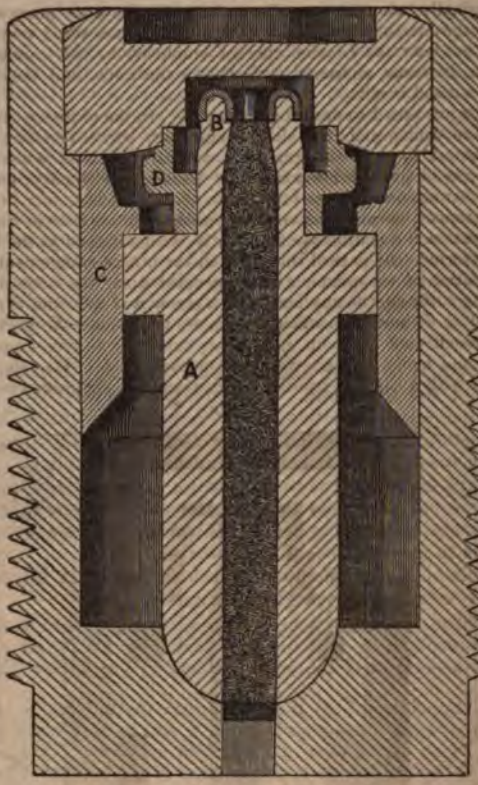
It consisted of an external case screwed to fit the shell, and containing a central pillar, which had a hole through it filled with powder, and which was tipped at the upper extremity with a detonating composition. This extremity projected into a cavity in the cover, a clearance being left of about half a tenth of an inch all round the detonator.

It would be seen, that if the pillar were to move forwards or to one side, the detonator would explode, by striking in the one case against the top, and in the other against the side of the cavity. It was therefore necessary to secure the pillar in its central position, in order to be perfectly safe in transport and in handling. This was effected by applying a leaden hoop, called the guard, which filled up the space around the pillar, and prevented any lateral movement. The hoop also rested upon a collar in the pillar by means of a flange, and abutted at the upper end against the cover, thus preventing any longitudinal movement. In fact, until the guard were dislodged, the pillar did not admit of any movement whatever. This, then, would be the condition of the fuze before the gun was fired; and in that condition (as represented in Fig. 1,) it was capable of resisting any amount of accidental violence to which it could be exposed. But when it was fired from the gun, the motion communicated to the shell was so sudden and rapid, that the *vis inertiæ* of the guard caused the flange to be stripped off, and the guard to be lodged at the bottom of the fuze, as represented in Fig. 2. In this condition the pillar would have lost the support of the guard, but it would still derive support from a little leaden cup, which was called the regulator, because by increasing or diminishing the thickness of this cup the sensibility of the fuze was regulated to the required degree. In determining the strength of this cup, the object was to make it of such a thickness that the pillar should be retained in its position when the shell struck upon water, but not when it met with a greater resistance. Supposing the shell to strike its object—a ship for instance—point foremost; in that case the velocity of the shell was checked, and the momentum of the pillar would crush up the cup and bring the detonator into contact with the top. Again, supposing that the shell had been fired at a high angle, in which case it would fall upon its side; or that in consequence of grazing upon the water it should strike a ship sideways, the momentum of the pillar would take effect in a lateral direction, and the lip of the cup which projected into a recess in the cover would be cut off, thereby bringing the detonator in contact with the side. The action obtained by this arrangement was extremely rapid, because the amount of movement in the pillar was very small. Also because the detonator was in immediate contact with the priming powder in the pillar, and a strong jet of flame was instantly shot from the fuze into the shell. So rapid was the action, that in firing a 100-pounder shell against a butt, 18 inches in thickness, the shells were burst in the act of passing through the timber, and the shattering effects produced were most destructive.

The only point in this description which might not be quite intelligible to all present, was the nature of the force by which the flange of the guard was stripped off on the firing of the gun. A few words of explanation would, however, make that clear. Taking, for instance, a 100 lb. shell, fired from a gun of 7 inches bore, and assuming the maximum pressure of the gas upon the base of the shell to be 1000 tons. This pressure would be equally distributed amongst all the particles of the projectile, so that each grain-weight would, at the instant of greatest pressure, have a force applied to it of about 3 lbs. Now the guard of the fuze, which weighed 300 grains, formed part of the projectile, and would, therefore, have a pressure of about 900 lbs. applied to it, urging it to move. But that would have to be transmitted to it through the medium of the flange which rested on the collar of the pillar, and which, not being strong enough to bear a strain of 300 lbs. would break under the force applied. The guard, therefore, would not move forward with the shell, but would be left behind, until it was caught up by the bottom of the fuze-case.

Proceeding to another branch of the subject—muzzle-loading guns—he stated that his conviction remained unshaken, not only that breech-loading guns were superior to muzzle-loading guns, in the great majority of cases—more especially for naval use—but that the application of the breech-loading principle was mechanically practicable for guns of very large calibre. At the same time he would admit there were cases, as in open forts, where the guns would necessarily be left in an exposed condition, and could not have the care and attention of a garrison, and where any species of breech-loading machinery, however simple, would be objectionable. In all such cases muzzle-loading guns would be preferable, and it was therefore probable that they would always be, to some extent, required.

FIG. 1.



PILLAR FUSE—Condition before firing the Gun.
A, the Pillar. B, the Detonator. C, the Guard. D, the Regulator.

The first consideration in a muzzle-loading gun was facility of loading, and to accomplish that it was necessary that the guage of the shot should be sufficiently low to prevent it from sticking in going down the bore. But, on the other hand, it was necessary, in order to insure accuracy of fire, that the shot should not admit of any lateral movement as it issued from the gun; the question, therefore, was how to make the projectile go in easily, and come out tight."

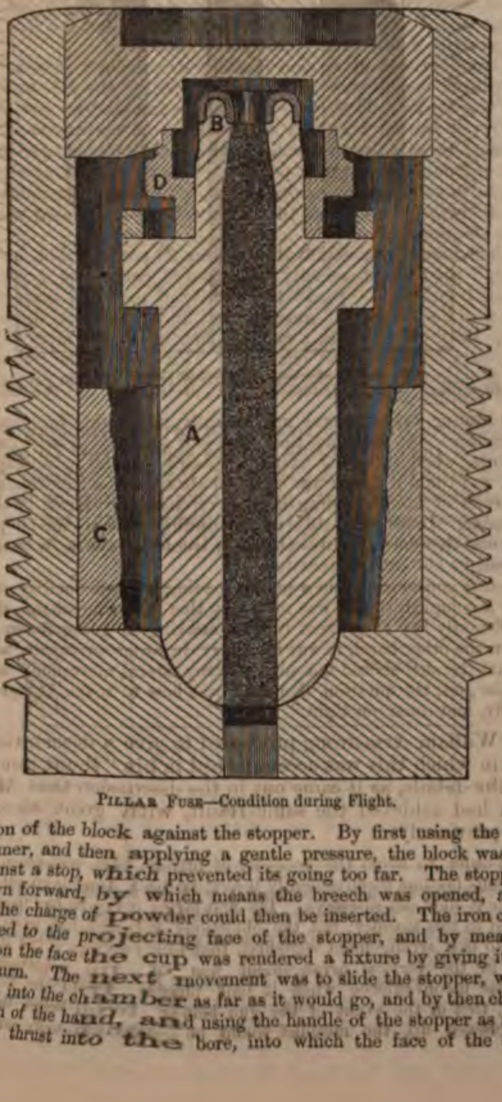
Sir William Armstrong proceeded to give a description of the mode in which this was accomplished in his "shunt gun;" but we omit the details, as it came out in the discussion that Mr. Whitworth had achieved the same result, with great success, four years previously.

"In order to avoid the necessity of lifting the vent-piece, which in large guns became inconveniently heavy, he had long been endeavouring to make it slide out sideways. The first large gun he had made was constructed in this manner; but the objections which had presented themselves to that arrangement were first, that the escape of gas at the breech, which in the vertical arrangement was of no importance, became a serious inconvenience when it took place from the side; and, secondly, that in the event of the gun being fired before the vent-piece was screwed up, the mischief would be much more serious, than if the opening were at the top of the gun. He did not, at the time, see how the difficulties could be surmounted, but he had at length arrived at a construction by which the object could be accomplished without the liabilities described.

A full-sized model of the breech of a 100-pounder gun, constructed upon this principle, was exhibited; but before describing it he would observe that the problem to be solved was, first to construct a breech-closing apparatus which would work from the side, so as to obviate the necessity of lifting the parts; secondly, to entirely prevent the escape of gas; and thirdly, so to arrange the apparatus that the gun could not be fired until the process of closing the breech had been perfected. The first step towards the attainment of this object consisted in the application of a thin iron cup, to act upon the principle of a pump-leather in preventing the escape of gas from the breech. This had been applied to the ordinary 100-pounder guns, and was found to answer perfectly. The Prussians originally adopted a cardboard cup for the same purpose, and for small charges, such as they used, that substance answered very well, but it would not bear the heavier charges employed in this country. Thin sheet-iron, however, answered perfectly for the cups, and they could be made at a small cost.

He then proceeded to describe the model. In the ordinary construction of the Armstrong gun, the slot or chamber, which received the vent-piece, was cut through the gun in a vertical direction, whereas in the model it passed through horizontally. This slot or chamber contained a stopper, corresponding in its function to the vent-piece, but in this case called a stopper, because the vent was in the gun and not in the stopper. It also contained a sliding-block, slightly wedge-shaped at the back, and which performed the part of the screw in the other arrangement. Where the prevention of the escape of gas depended upon the mere pressure of well-fitting surfaces, the application of a screw was requisite to render the contact of those surfaces sufficiently close; but where the prevention of escape was effected by a cup, it was only necessary to give support to the stopper—and hence the screw was dispensed with. The sliding-block was fitted with a running handle, which acted as a hammer in overcoming the friction of the block against the stopper. By first using the handle as a hammer, and then applying a gentle pressure, the block was thrust back against a stop, which prevented its going too far. The stopper was then drawn forward, by which means the breech was opened, and the shot and the charge of powder could then be inserted. The iron cup was next applied to the projecting face of the stopper, and by means of a button upon the face the cup was rendered a fixture by giving it a portion of a turn. The next movement was to slide the stopper, with the cup affixed, into the chamber as far as it would go, and by then changing the direction of the hand, and using the handle of the stopper as a lever, the cup was thrust into the bore, into which the face of the stopper entered about half an inch. It then only remained to draw up the block, and the process of closing the breech was completed.

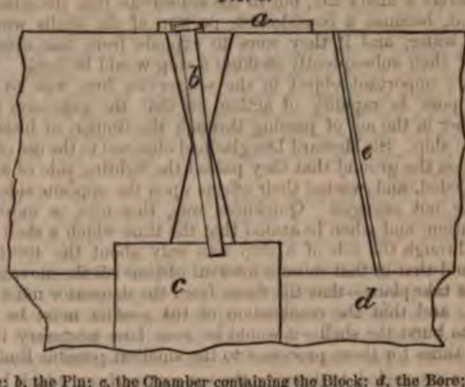
Fig. 2.



Pillar Fuse—Condition during Flight.

It would be observed that the stopper, in coming out, was guided into a convenient position for affixing the cup by means of two grooves, one on either side of the chamber, and that in going in these grooves prevented any devious or vibratory movements in the stopper, which would have the effect of bringing the cup in contact with any part of the gun, and thereby bruising its edge. But the grooves were also of such a form that when the stopper had reached a point opposite the bore, then, and not till then, it became susceptible of the movement necessary for entering the cup. It would also be perceived that the stopper, in coming out, was arrested at the proper place, so that it could not tumble out. But although it could not come out accidentally, it could be easily taken out designedly, by guiding it into a sort of siding running out of the groove.

Fig. 3.



a, the Slide; *b*, the Pin; *c*, the Chamber containing the Block: *d*, the Bore; *e*, the Vent.

The apparatus for preventing the gun from being fired before the breech was properly closed, was then described.

On the top of the gun there was a little slide which worked to and fro over the vent-hole, and which participated in the motion of the block so as to cover the vent-hole when the block was thrust back, and to uncover it when the block returned to the position at which the gun might be fired with safety.

The apparatus by which this was effected was very simple. It merely consisted of a little slide and of a strong pin communicating with the block through a hole, which was contracted in the middle and expanded above and below, as shown in Fig. 3. This form of hole allowed the pin to vibrate on its centre. The lower extremity of the pin projected into a groove in the block, which groove had a curve upon it to give the required movement through the gun to the slide. The slide was covered by a hood, shown in the model, but for the sake of distinctness not indicated in Fig. 3.

A 100-pounder gun upon this principle was now completed, and would be tried almost immediately. He had the greatest confidence in its success, as the details had been worked out with great skill and care by his able friend, Mr. George Rendel, the managing partner of the Gun Department of the Elswick Ordnance Works."

According to Mr. Aston, there are some points very much in common between some of the contrivances above described and those which have been long used by Mr. Whitworth. Mr. Aston observed that—

"There was another point which must have been heard from Sir William Armstrong with much satisfaction. That was a recognition of the muzzle-loading principle, as one which, under many circumstances, must ultimately be adopted. The muzzle-loading principle did away with a vast amount of complication. It reduced that which entailed great difficulty in manufacture, and great delicacy in management, to simplicity of manufacture, and safety of management; and, therefore, it was gratifying to hear it confessed by so high an authority that, under certain circumstances, the muzzle-loading system must inevitably be recurred to. With regard to this newly-proposed system now explained and advocated by Sir William Armstrong, Mr. Aston could only say, that in several points it exemplified in a remarkable degree how possible—nay, how natural—it was, that two minds, pursuing the same course of discovery, should hit upon plans which, though not perhaps identical, yet nevertheless involved the same principle. It was stated, that in the shunt gun proposed by Sir W. Armstrong, the projectile, when it was pushed into the gun, entered with an easy fit, and that when it came out it hugged the tight side, and came out with a tight fit. Sir William likewise stated, that for two years he had been devoting his attention to working out this new principle, which was to take the place of his old principle. Now it was generally well known, that before the period embraced within those two years, that principle of having an easy fit for the projectile as it entered, and a tight fit as it left the gun, had been practically applied to Whitworth rifled artillery with great success. In some muzzle-loading guns which were still at Shoeburyness, and which had been there four or more years, that principle was most successfully carried out. He alluded to the brass field-guns rifled by Mr. Whitworth for the government, and tried at Shoeburyness some years ago. He did not for a moment wish to say that Sir William Armstrong had been guilty of plagiarism, but it was evident that the same principle had been adopted, whether knowingly or otherwise, by two minds. To what extent it has been worked out in a similar, or dissimilar manner, he must leave to the opinion of those who were familiar with both the systems, and doubtless they would form their own judgment. A contrivance had also been mentioned, by which the escape of the gas was prevented; it was based upon the principle of employing a thin iron or tin case, which was inserted in the breech end of the gun. Now this bore a very close resemblance to the metallic cartridge which had been so long used by Mr. Whitworth, and had proved so efficient in his breech-loading guns. Again, with regard to the closing of the vent by means of the sliding guard, which had been explained to the meeting, many gentlemen present had seen a rifled breech-loading cannon, wherein a similar slide connected with a screwed breech-cap was employed; it was used to cover the vent when the piece was not ready to be fired, and it was withdrawn only at the time when the breech piece was "home," and the gun might be safely discharged.

Mr. Aston alluded to these matters, to show how, in these three instances, two minds appeared to have travelled one after the other in the same groove, with the desire of effecting similar objects."

The question of priority as between one inventor and another is however of very small consideration in comparison with the question, What is the best system of ordnance, and how is the country to be assured that the best has been or will be adopted? On this point we quote a portion of the President's concluding speech.

"The members were all interested in the explanation afforded by Sir William Armstrong relative to the progress of his guns; and the manly feeling which dictated the throwing aside of all secrecy, demanded the admiration of all who heard him. It was most satisfactory to hear his indignant disclaimer, that he had any part in preventing the trials that were to have taken place relative to the results of his mode of rifling as compared with that adopted by Mr. Whitworth. No doubt Sir William felt assured that a fair trial would satisfy the public as to all the improvements he had introduced, which had the elements of success in themselves; and if any competitive trials had shown that anything better could be done, no man would have received the verdict more willingly than Sir William Armstrong himself.

Sir William had expressed an entire want of confidence in homogeneous iron. The President could not concur in that view; he did not think that at present they would be justified in saying that homogeneous iron had ever yet had a fair trial and had been found wanting. He had received a letter from Mr. Krüpp, of Essen, accompanied by a communication from Colonel Petiet, of the Artillery Commission of France, stating as the results of his experience with 12-pounder guns constructed of homogeneous iron, that they had been completely successful. Mr. Krüpp stated that in Prussia they had made guns of 8-inches bore, which had successfully resisted all the proofs to which they had been submitted. There could be no doubt that in this country there had been some disappointment attending the manufacture of guns of large calibre, of homogeneous iron. This, however, might be fairly attributed to the mode of manufacture. The machinery for working the iron in the large masses necessary for guns was not suitable for the purpose; and until hammers of 30 or 40 tons were applied it would not be fair to pronounce the condemnation of homogeneous iron as a material for artillery; indeed, they were not justified in rejecting homogeneous iron for guns until the same experience had been gained and the same attention had been bestowed upon that metal, as had been given, under Sir William Armstrong's superintendence, to his own peculiar mode of construction.

Sir William Armstrong had explained very lucidly the mode of operation of the shunt gun, and expressed his conviction of the adaptability of projectiles with a soft metal coating to guns of large calibre, and that they were even superior to the hard tool-prepared projectiles. That, was *de facto* the question of the comparative merits of the systems of rifling adopted by Sir William Armstrong and by Mr. Whitworth, and upon which it had been hoped that the trials which were proposed last year would have afforded conclusive evidence. The President was bound to say that his own conviction was in favour of the hard tool-prepared projectile, and for these reasons:—He had seen a great many experiments with Whitworth guns, he had examined carefully the results of numerous trials, and he had received within the last few days the results of some comparative experiments made with Armstrong and with Whitworth 12-pounder guns at Shoeburyness, by the Ordnance Select Committee. Those results were highly interesting, and they pointed to suggestions of great importance in the science of artillery. The document was a private report issued by the Select Committee, and he had obtained a copy of it from Mr. Whitworth.

Sir William Armstrong observed that it had never come under his notice in any form whatever.

The President believed that it had been kept very quiet. He had seen the original report, and, in fact, had ordered a fac-simile of it to be printed for insertion in the minutes. He hoped this meeting would not suppose that he was making statements which could not be substantiated. This circumstance induced him to remark that it was the duty of any committee appointed by any government department, not only to investigate most carefully a subject of this importance, but to record all their proceedings, and the results they arrived at, and to publish them with authority, in order to satisfy the country. There was not any mystery or craft in the science of artillery, and the results of the innumerable trials that had taken place ought to be made public. What had Sir William Armstrong himself stated in the course of this discussion? He said, that up to this moment the law of retardation with reference to projectiles had not been ascertained, whilst with the experiments of the last twelve months the facts might have been observed, and the law could have been determined with the greatest nicety.

Sir William Armstrong said there was a separate law for different descriptions of projectiles.

The President replied that there were separate results, but there could only be one law for all projectiles; therefore, in the operation of rifling two things had to be attained—in the first place, the highest rate of initial velocity; and in the second place, the projectile should be exposed to as little retardation as possible from the atmosphere. It would appear, from information supplied by Sir William Armstrong, that the initial velocity of the projectile with the same charge of powder was nearly the same in the Armstrong as in the Whitworth gun; but the retardation of the Whitworth projectile was less than that used by Sir William Armstrong.

The Report of the Ordnance Select Committee (annexed) would illustrate the President's views. The practice in each case was certainly beautiful, and it demonstrated a most material point. If the initial velocity was the same—and from the facts supplied it would appear to be so—still from some circumstances, probably from the form of the Whitworth projectile, it was exposed to a less amount of retardation. The law, as far as he had ascertained, would seem to be that an allowance must be made of 1 per cent. loss of velocity for every 100 yards traversed. He found from the result of the experiments at Southport last year, that with a 12-pounder gun at 35 degrees of elevation, the ball was thrown to a distance of about 10,000 yards, and the time of flight was 40¼ seconds—the longest period upon record. The importance, then, of this law of retardation could hardly be sufficiently appreciated.

Mr. Longridge was of opinion that the experiments should be continued until the means were attained of projecting the rifle bullet with the same velocity as a 68-pounder shot from a smooth-bore gun. There were, however, reasons why that could hardly be accomplished; either the gun must be of a length which would render it unmanageable, or it could not consume the charge of powder. The velocity of a 68-pounder shot was stated to be 1700 feet per second, whilst the experiments with the Armstrong gun showed that the initial velocity of the shot was about 1200 feet per second.

It must be borne in mind that the ordinary 68-pounder shot, instead of losing only 1 per cent. of velocity in every 100 yards, lost 6 per cent., whilst after travelling 800 yards, the velocity of the rifled projectile exceeded that of the ordinary 68-pounder; and, in point of fact, the penetration of the rifled projectile at a range of four miles was more than that of the ordinary 68-pounder at one mile. This showed the influence of the force of retardation, and the importance of reducing it in projectiles to the lowest possible amount."

On examining the table referred to by the President, we find the object of the experiments is thus specified:—"To ascertain range and deflection." A glance at the two columns headed "Mean observed deflection," gives strong presumption as to the superior lateral accuracy of the Whitworth gun; but for more exact comparison we put side by side the deflections in each case as referred to the mean direction.

Charge.	Elevation.	Armstrong deflection.	Whitworth deflection.
lb	Degrees.	Yards.	Yards.
1·50	2	1·04	0·75
1·75	,,	1·48	1·08
1·50	5	1·48	1·72
1·75	,,	0·80	0·64
1·50	10	2·14	0·85
1·75	,,	6·17	2·92

On comparing the above figures it will be seen that the greater lateral accuracy of the Whitworth as compared with the Armstrong gun becomes most conspicuous at the 10° elevation, *i.e.* at the longest range.

It is equally evident that the Whitworth gun is *facile princeps* as regards range. At the furthest ranges it distances its rival by 490 yards, or more than a quarter of a mile.

clusion announced by Col. Lefroy. Some curiosity may exist as to the mode in which a result so original has been arrived at by the Ordnance Select Committee. The method, in a word, is this. A horizontal rectangle is computed of such length and width that (according to the tubulated record of the experiments it is as likely as not that a shot would fall within it. The area of this rectangle is taken as the measure of the inaccuracy of the gun. This may be well enough when the two guns are equally well managed. In the presentcase, the practice with the Armstrong gun was steady and good as to range; that of the Whitworth gun so wild as to be quite unreliable for data. The rectangles found with so much mathematical exactitude are therefore simply delusive. Their only use is to cast a cloud of figures over a very simple question of facts, and confound the marvellous lateral accuracy of the Whitworth gun with the random results of bad handling as regards range. After this, few will be surprised that Mr. Whitworth asks to have his guns worked by his own men.

The paper of Mr. Bidder, jun., and the discussion to which it gave rise, dealt with the National Defences in the broadest sense: we have confined our view to one point,—an all-important one, which it is time were settled. We are glad that a body so competent to deal with the subject, and of such high standing in the scientific and practical world, have directed their attention to the matter, and we hope that they will continue to watch it and make their voice heard upon it, until the much-vexed question is set at rest. Whatever disarmaments may be mooted under the pressure of financial difficulties by neighbouring powers, the day is distant when England can be careless as to her defences, or indifferent as to the excellence of her artillery. Let there be the impartial, public, and conclusive competitive trial of which both inventors profess to be so desirous, and let the best gun be adopted.

ARCHITECTURAL STUDY AND ARCHITECTURAL PROGRESS.

Address to the Architectural Association.—Session 1861-2.

By A. W. Blomfield, President.

The Opening Meeting and Conversazione of the Architectural Association for the new Session were held at the Architectural Union Company's premises in Conduit-street, on the 25th October. The President, Mr. W. Blomfield, delivered the address, from which we make some extracts. He said—

After numerous perils and vicissitudes, the Architectural Association is now about to enter the sixteenth year of its existence, and we may fairly hope that it will prove to have outgrown most of those youthful disorders which have more than once (with the assistance, perhaps, of friends and doctors), brought it very nearly to a premature end. It will be our own fault if it does not continue year by year to enlarge its sphere of usefulness, and to satisfy more fully a want which, I have no hesitation in saying, would even now be keenly felt by a considerable circle in the event of its dissolution.

We have heard an encouraging report of the proceedings of last session, and I need scarcely remind you that in the year before us we shall have rich opportunities of observation and study in the forthcoming Great Exhibition, which cannot fail (if we use our time properly) to produce a good effect in developing what I apprehend to be the great end and object of this association, viz., "Mutual assistance and improvement in prosecuting the study of architecture as an *art*." I lay this stress on the word art, because I feel that into some of our discussions too much of what I may call the business element finds its way, to the no small detriment of that artistic progress which ought, I think, more exclusively to occupy our attention as students. I must not, of course, be understood by this to undervalue the business element in its proper place, nor to deny in any way its indispensable necessity to every architect in practice. But as a body we are not in practice, and whether in practice or not we are still young, and the majority of us at least have that time now to devote to artistic self-improvement which each successive year will render it more difficult to find. It seems to me that in an association of this kind, composed of students (for we are all students, r the most part, young students), more real practical would be done by the members uniting as one man g to understand thoroughly, and help forward honestly, the development of true principles of art, than in discussing questions which might well be left to those whose opinions when published are likely to carry weight and authority. The nearer, in fact, we approach the character of a juvenile debating society, in which the most difficult political questions of the day are gravely discussed and decided by an assembly of beardless youths, the further shall we be from reaching any useful result. Banded together and firmly united in a common honest purpose, as art students determined to carry out true principles at any cost, we may and must work out great and lasting effects on the progress of architecture. This, to my mind, is our proper province, and as it is a point that has perhaps been rather lost sight of in the last few years, I purpose this evening to address myself more directly than is usual on these occasions to the members of this body.

During the past session a very great deal has been said, and I believe something has been done, towards the settlement of that long-mooted question, the establishment of an architectural examination. The subject has naturally excited much interest amongst ourselves, more especially as I believe it was by the association that such a proposal was first started. Many—I believe I may say a large majority—confidently foretell that such an examination, when fairly set going, will have the effect of raising the standard of the profession, and of excluding ignorant and incompetent persons from practising as architects. This result is, no doubt, much to be desired; but as I have already publicly expressed my opinion, with the reasons for that opinion, and found myself in a small minority, I will not enter on the subject now. I cannot help noticing, however, that in the course of the various discussions which I have read and heard, several theories have been alluded to as acknowledged truths, which have struck me with extreme surprise. For instance, I have heard it casually stated, as a matter of course, at one of these discussions, "that a young architect should study every style, in order to be ready to meet the possible wishes of his client." Now, of course, in pronouncing this theory to be simply monstrous, I have no wish to set a limit (especially in this direction) to the study of all that is great and good in art of every period and every clime; but the idea of attempting to carry out the theory of practising every known style, to me, I must confess, suggests nothing so vividly as the conjuror's inexhaustible bottle, which is always ready with a modicum (and that sufficiently bad, be it remembered) of any liquor that may be asked for. The counter theory is that a man must be full of one style, just as a bottle must be full of one wine to give it really good.

The rapid and apparently perfectly natural and easy change from one style to another of totally opposite principles will to some mindss mack more of the dexterity of the charlatan than of the sober earnestness of purpose of the true artist. But we are told that "we ought to be ready to meet the wishes of our client—to bow to his choice of style." Our client, on the contrary, if we were united in purpose, as we ought to be, or, in other words, if ours were an age of true art, should have absolutely no choice as to style. A patient does not tell his physician what medicine to give him—he tells his symptoms, and the doctor prescribes; so your client should tell you his requirements, the money at his disposal, and so forth, and these you should scrupulously attend to; but have no self-doctoring on his part, no interference in your especial province: here the artist should reign supreme.

It may well be doubted whether architects, as a class, do not tell their clients, the public, too much about the names and outward characteristics of various styles in an easy, smattering manner, which leads them to believe that they not only may, but are invited to choose for themselves, as the caprice or fancy of the moment may dictate. It is ten to one that when we hear an old gentleman in public or private discussing the relative merits of Classic and Gothic (a subject of which he is most likely profoundly ignorant, and for which he really cares not a straw), he is making use of hackneyed terms and threadbare descriptions which we architects have put into his hands, and which he flings about as intelligently and usefully as a boy throwing stones in the street. No doubt, one of the most formidable difficulties a young architect can have to encounter in commencing his career is to make people (particularly friends who only think about his "getting on") understand clearly that he has such a thing as principle, which prevents him from attempting to practise a variety of styles; and the sooner he faces this difficulty boldly and grapples with it, the better for the public and the better for him. Let him, by all means, study good art of every description, would vault over his space, the plans or horizontal sections of the different stages followed with unvarying certainty; so much so, indeed, that an inspection of any one of these plans would enable a man versed in the subject to trace the vault tolerably correctly without seeing it. Now, of all the young architects of our day who would complacently undertake the erection of a church in "the Gothic taste," how many do you suppose could do this? We will not inquire too curiously, but I believe if it were known, I should be held excused for insisting thus on what appears to be a self-evident truth.

That the present position of our profession is not as high as it ought to be, is painfully evident from the unmerited slight which has during this year been passed upon it. As we all know, the monster which is now rapidly developing its vast anatomy at Brompton was hatched as it were by magic, without the decency of even a nominal architectural incubation. The defence of the course pursued which has been attempted by some of the daily papers, viz., that architects had forfeited all claim to consideration by not having produced the successful design for the Exhibition building of 1851, is transparent and futile in the extreme. That building was temporary, and there was a competition in which numerous designs were received for it. Much of this building is to be permanent, and there has been no competition: none the less surely on that account, however, will it shed lasting credit or lasting disgrace (as the case may be) on the architectural taste of the country, and so on the architects. It would perhaps be premature at the present time to offer any criticisms on the building, more especially as, from the latest published views, it is evident that some embellishing hand has been touching up many of the details since the first perspective burst upon the astonished world in all its breadth and baldness. The confectioner has already begun to decorate the cake. If criticism, however, holds her tongue and bides her time, predictions of the most laudatory character are not wanting. When we are told, for instance, that "the entrance to the principal picture-gallery in Cromwell-road will be through three noble recessed arcades," that "they are each 20 feet wide and 50 feet high, and will look as imposing in their quantities as the principal façade of St. John Lateran, at Rome, and other Renaissance porticos of Italy," the mind is awe-struck at once, and we begin to get up our enthusiasm; but the effect of this high-flown language is rather impaired, perhaps, when we read of another portion of the building—"How this part may be best decorated time will show;"—time thus taking the place of "the architect" quite naturally. After bathos such as this, we cannot do better than take refuge in the number of girders, shoes, bolts, &c., which will be used; the quantity of putty; how far the iron columns would reach if placed end to end, and details of this kind which are given in endless variety, and are believed, I suppose, to convey some definite notion of the size of the building to the vulgar mind. But, after all, when finished and in operation, it will not be the beauty or ugliness of the building which we shall care for; we shall not be looking at the casket, but the gems which it contains. So let it pass; if it answers its purposes of light, accommodation, and so forth, it will do more than many another building of higher pretentions, and we must not grumble. We shall have plenty to do in the various departments connected with our art, and more particularly in comparing the architectural progress of other nations with that of our own. It may fairly be presumed that with the comparatively speaking small space at their disposal, the Architectural Committee will reject all but works of real interest and importance, so that every drawing will be worthy of attentive examination.

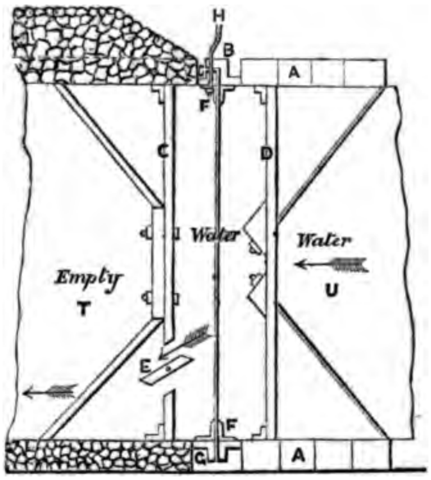
It is truly refreshing to turn from all this bustle of preparation and excitement to the quiet contemplation of a most remarkable and beautiful building which has been completed within the last year. Time warns me that, instead of reviewing the architecture of the year, I must confine myself to the notice of this one building; but I feel no scruple in mentioning the church of St. James-the-Less, in Garden-street, alone, as in many respects it stands pre-eminent amongst modern churches, and, moreover, it exactly illustrates the principles to which I have so briefly and imperfectly alluded to-night. It would be an impertinence on my part to offer any criticism, or to speak in any ordinary terms of admiration, of this church. Therefore, I can only say to all lovers of Christian art,—Go and judge for yourselves: you will there find real originality—that originality most to be desired—the ult of a man having all his life continued diligently to collect erials for the exercise of his genius. You will find all in harmony, for each part, and every detail has been thought over and worked out with a loving hand and an artist's eye. The whole of the building and its decorations (with, perhaps, one exception), bears the impress of one powerful mind. You see at a glance that the building was not, as is too often the case, planned so as to be carried out with least bother and trouble to the architect, and then handed over to the tender mercies of the ecclesiastical decorator and upholsterer, to make the best they could of the frigid carcase, but the design of the smallest detail forms an essential part of the whole. I will say no more than to recommend the eager student to go there to admire and learn, and the lukewarm to have his wavering fancies fixed, his enthusiasm stirred, and his energies braced to the work before him. Such a work as this places the fact beyond any dispute that real progress has been made in architecture in the last few years.

REVIEWS.

The Channel Railway, connecting England and France. By JAMES CHALMERS. London: E. and F. N. Spon, 1861.

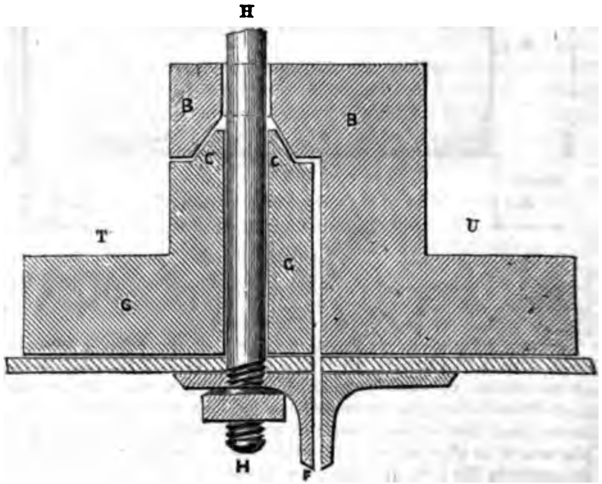
The plans of Matthieu, De Gamond, Wylson, De La Haye, and others, for connecting the railways of England and France, have prepared the public mind to consider the matter coolly and patiently, if they have effected no other object. The work before us details the plans of Mr. James Chalmers for connecting the railways of England and the Continent of Europe by a submerged tube running from the coast of England, about a mile east of Dover, to the coast of France, about seven miles west of Calais. We have more faith in the practicability of Mr. Chalmers' general scheme, as well as in his contrivances for operating under water,

FIG. 1.



1-16th inch to foot.

FIG. 2.



1¼ inch to foot.

also supported by the T-iron, DD, and the ceiling has similar supports on its upper surface. The plates are calculated at 36 inches wide, lapping 3 inches, and two circles of T-iron are calculated for each plate; but I propose using three for deep-water tubes, two for medium, and one only for those in shallow water near shore. Thus, with three ribs of 5-inch T-iron to each plate, the space between the top tables, or part of the T-iron rivetted to the plates, will only be 6 inches, or 11 inches from centre to centre of the ribs, the T-iron and laps exactly equalling in extent the interior surface of the tube, thus, as it were, doubling its thickness, and by the form adopted, more than trebling its strength. The interior supports just described—the partition, girders, and ceiling—sustaining the tube at six points of its circumference, and the exterior support it will receive at ten points of its length from the sides of the iron boxes attached to and surrounding it, will render it the strongest and most economical tube that can be made to resist the combined forces of compression and lateral strain."

Mr. Chalmers' estimate of cost is £12,000,000, and three years, he thinks, would suffice to complete the work. He gives full details, and the data on which he bases his estimate. If his estimate is well founded, the undertaking would be a source of direct profit; and the connection of the English and Continental railway systems would be a great benefit to the communities on both sides of the Channel.

The History of St. Mary's Abbey, Melrose, &c. By JAS. A. WADE. Edinburgh: T. Jack. London: Hamilton, Adams, & Co.

This is a work which the present revived taste for archæological study and illustration has contributed to call forth. Its object, as its title imports, is to give a history of the Abbey of St. Mary—the Monastery of Old Melrose—and the town and parish of Melrose.

As respects the latter, which commences the volume, and forms the first chapter, it is stated to be a reprint of a treatise published in 1743, and written by the Rev. Adam Milne, officiating minister at Melrose from 1711 to 1747.

This description of the parish is full of topographical and other information on the subject, and forms a proper and satisfactory prelude to the succeeding chapters, which comprise respectively the history of the old and the later monastic foundations, the present state of the remains, some observations on monastic life, with a biography of the abbots of Melrose, and a general account of the most interesting sites and objects in the locality.

The history of the old monastery and the observations on the monks of Melrose are comprised in the 2nd and 3rd chapters. The architectural description of the ruins, with the tombs, &c., is given in the 7th, 11th, and 12th (the intermediate ones being devoted to an historical summary of the town and abbey generally, and the biography), and the 13th or concluding chapter to the local particulars.

The history contains all the facts connected with the original and later establishments, and with the vicissitudes of the same from the earliest period to the time of the suppression; and the observations on monasticism and monkish inner life are interesting.

The architectural descriptions appear to be very diffuse, but would have been better for professional revision; they are clearly the descriptions of an amateur, and are not always, architecturally speaking, correct. At page 174 it is said, "the roof of the high altar is uncommonly beautiful." The roof meant is apparently that of the eastern termination of the church, and as such would have been more correctly referred to as *over* the high altar. At page 175 we have the following—"Within the walls of the chancel are *fonts for holy rites*, and *recesses* for containing the vessels of the *sacristy*." These are, doubtless, the piscinas and aumbries usually found adjoining the sites of old altars. In the same page we have reference to a circular or rose window, as resembling a *crown of thorns*, which it is certainly necessary, after the old Greek fashion, to mention, since no likeness is to be discovered in the illustration of it given at page 176.

The following modes of description at page 178 are particularly to be objected against as contrary to correct architectural expression. "The north aisle is conspicuous for the *neatness* of its pointed roof, &c.;" "their capitals, representing leaves of plants and flowers, are all *classically* chiselled." What is the *neatness* of a Gothic pointed roof? and how can Mediæval foliage be said to be *classically* wrought? At page 181, again, what are *false Gothic arches*, and what are wreaths of flowers springing from *pilasters*, (in a Gothic arcade!) at the sides of the arches? Do not these *wreaths* represent the usual decorated crocketting, and the *pilasters*, buttresses? Such they would undoubtedly appear to do by the illustration showing the east wall and angle of the cloister.

Speaking of the view of the ruins from the roof, there is another curious expression at page 183. It is there said, "Ascend the stair, which winds like a *snail cap*, and look," &c. Surely this would have been more intelligible had the usual term of vice or newel stair been employed. Again, at page 185, we have the following, to say the least, strange kind of description:—"The mark of the chisel on the best carved stones is sharp, light, and wonderfully accurate in touch and tone. The stones lie disposed in the building as they chiefly lie in the bed of the quarry—they rest on the horizontal line, and are consequently only compressed thereon." "The grooves are all exquisite, and the jointure of parts clean and faultless." This cannot be properly called architectural description. What is to be understood by the *tone* of the chisel mark? And why not say, in reference to the disposition of the stones, in words much less roundabout, that the stones are laid according to their natural course or bed in the quarry, which in all good old work is the usual way; as for the "exquisite grooves," this is quite unintelligible. Of a parallel kind are the words used at page 188: here it is said, "the mouldings are sharp, the pillars elastic (elastic pillars!) light, and graceful, the *perpendiculars* (what are they?) slender and harmonious, the carvings elaborately correct and *classically* (classically again!) severe." Mr. Wade appears to have a particular liking for classic reference. He says, in the same page, "The light touch of the Greek artist is prominently conspicuous in the east end; the massive Roman and the coarse Gothic are everywhere subdued." Further on we have the following strange phraseology—"Look at the foliage and *plant work—curvilinear gems*." Throughout this portion of the work there is much of this sort of language which it would have been far better should have been omitted, since, not clothed in proper architectural and natural dress, seeking to reach the sublime, it in many cases descends to the realisation of the old proverb.

The historical summary and biography contained in chapter 8 is at once concise and valuable. The description of the ruins, however, forming chapter 11, is open in many parts to the same objections as those referred to in connection with the other architectural notices; there are also some repetitions of the former incorrect wording. At page 297 we are again, and in the same words, referred to the *neatness* of the pointed roof of the narrow north aisle,—and to the capitals of the pillars, the ornamentation of which is here, however, more correctly stated to be *tastefully* chiselled. At page 310 we have the most extraordinary announcement, that "even every pillar *in the interior* of the church *shot up through the roof* into a pinnacle, adorned with niches," &c.; how this novelty was effected Mr. Wade does not particularly say, nor does his restored view of the abbey church show it. What is probably meant is that all the buttresses externally terminated in niches and pinnacles.

There is also an incorrectness in the description of the east end of the church; "the choir, or chancel," it is said at page 306, "is built in the form of half a Greek cross, the east end of it, which was probably a chapel of the Virgin Mary, being only half the breadth of the part next the transept." This is not properly stated,—the church, judging from the plan given, was evidently in the more usual form of a Latin cross. In a previous part of the work it is stated to be in the form of a St. John's cross; though in what this differs from the former is not mentioned,—comprising nave, choir, transepts, with eastern aisles, and two projecting chapels therefrom in connection with and projected upon the eastern portion of the choir, which might possibly have been appropriated, considered as a sub-arrangement, as the chapel of the Virgin. The ancient choir, it is probable, extended far beyond what present use seems by the plan to confine it to, and as part of this extended and original length, it is very wrong to describe the eastern end as half a Greek cross. It is an associated and connected part of the whole plan.

Divested of this kind of inaccuracy of diction, &c., and setting aside such exploded notions as that I. H. S. (see page 309) indicate Jesus Hominum Salvator, instead of being the abreviated form of the holy name, the notices of the ruins given by Mr. Wade, with the accompanying illustrations, are by no means uninteresting in many ways, and, together with the facts and matter of the other portions of the work, speak favourably for the industry of the author, and show strongly the *con amore* spirit with which he has followed his labour. The references to the tombs in the abbey church, and the other objects noted soft nature of the banks rendering them unable to resist the action of the waters in the dry season. The depth of water at the junctions of the rivers with the Ganges varied with the time of the year, and also from one year to another; and sometimes, as in 1853, the three rivers were almost closed. The quantity of water from the Ganges discharged by these rivers varied greatly. It had been stated by Major Lang, formerly superintendent of these rivers, that in a high flood it amounted to 200,000 cubic feet per second, whilst in the month of March, it did not exceed 5000 cubic feet per second, of which a large portion was derived from filtration.

The author next proceeded to give a detailed description of the navigable channels of the Hooghly, and referred particularly to the report of a committee appointed by Government in 1853, to inquire into the state of that river, and to the evidence given before that committee. In concluding this part of the subject, he said that the river might be divided into three sections. First, from Calcutta to Fulta-house, a distance of about 34 miles, with an average high water width of 1300 yards, it consisted of a series of deep but narrow channels, separated by bars at the points of inflexion of the curved reaches. In this part of the river the navigation, though tedious and troublesome, was not dangerous; and though subject to periodical annual changes, the depth of water did not appear to have suffered any permanent deterioration. Secondly, from Fulta-house to Culpee, a distance of 24 miles, the high-water width widened out from 1 mile to 2¾ miles. This section embraced the junction of the Damoodah and Roopnarain rivers on the right bank, and the dangerous James and Mary's Sand. The channels were subject to great and sudden changes; the tides and eddies were strong, with shifting sands. There appeared to be evidence of some permanent decrease of depth of water, though not yet to such an extent as to have a serious effect on the navigation. Thirdly, from Culpee to Sand Heads, a distance of 37 miles, the river widened out from 2¾ miles at Culpee, to 17 miles at Saugor point. This section contained many dangerous places, and the evidence went to show, that there was a decided and serious shoaling of the water, and a prolongation seawards of the tails of the sands below, to an extent of not less than 6 miles, within the last fifty years.

In reference to the tidal phenomena of the Hooghly the information was extremely scanty. An analysis of the observations made at Kidderpore Dockyard, near Calcutta, from 1st July, 1843, to 30th June, 1844, showed: First, that the duration of the flood was three hours during the freshes, and four hours during the dry season; whilt the ebb lasted from eight to nine hours. Secondly, that the mean rise of tide, on an average of three days, commencing with each quarter of the moon, was during the dry season, from October to February both inclusive, at spring tides 11 ft. 1½ in., at neap tides 7 feet; and from April to August both inclusive, at spring tides 12 ft. 2 in., and at neap tides 7 ft. 5 in. Thirdly, that during the north-east monsoon, from the middle of September to the middle of March, the night tides were higher than the day tides; whilst from the middle of March to the middle of September, when the north-west monsoon prevailed, the day tides were higher than the night tides. The mean velocity of the tidal wave, from Sand Heads to Kidderpore, was about 26¼ miles per hour.

The author estimated that the quantity of fresh water passing into the Hooghly from the Ganges, through the Nuddea rivers, was upwards of 60,000 million cubic yards per annum; and the opinion had been stated that the amount brought down by the Damoodah and Roopnarain rivers was at least equal to that from the Nuddea rivers. Also, that as the great bulk of this fresh water passed down during the inundations, when the rivers of Bengal were highly charged with sediment, he calculated that not less than 39,000,000 cubic yards of solid matter were carried down each year into the river and sea channels of the Hooghly below Calcutta, and an equal quantity from the Damoodah and Roopnarain rivers; so that 78,000,000 cubic yards of solid earth were probably deposited yearly in the Hooghly and its estuary. That this amount of solid matter was not exaggerated was evident from the statement of Major Rennell, that, in the flood season, the Ganges, from whence the water was derived, contained one-fourth part mud in its waters; and from that of Capt. Sherwill, that the annual deposit in the Bay of Bengal, from the Ganges and the Brahmapootra, amounted to 1500 millions of cubic yards.

As the soil of the Delta of the Ganges consisted of loamy sand and black mud, it was unable to resist the action of the stream, and thence the course of the river was subject to great variations, and its banks were continually changing. On the sea-coast of the Delta, there were eight openings, each of which had in turn probably served as the chief mouth of the Ganges. Of these, the Hooghly was the most westerly, and the Mutla—the third from the west—was about forty miles to the eastward of the Hooghly.

The Mutla was an inlet of the sea, rather than a river, inasmuch as the fresh water entering it was entirely confined to a small portion which drained off the adjoining lands during the wet season. Its depth was in no place less than four fathoms at low-water spring-tides, and the entrance was easy of access. It was free from bars and shifting sands, and the channel appeared to have suffered no material change from the year 1839, when it was first surveyed, to the year 1853, when it was again surveyed. It was entirely tidal, was not subject to freshes, and was free from the bore, at times so destructive in the Hooghly. At the head of the river, where it was proposed to establish the new port, there was space for two hundred and forty ships, and in the Edoo Creek for six hundred ships of the largest size, still leaving ample room for ships to swing in the stream. Excepting during the short period when the Nuddea rivers were open, the whole of the traffic to Calcutta from the Ganges passed across the Mutla.

Comparing the two rivers, the Hooghly and the Mutla, in regard to their facilities for navigation, and the general hydrographical features, it would be found, first, that the distance from the head of the Mutla to the sea, opposite Bulcherry Island, was 65 miles, whilst from Calcutta to Middleton Point was 99 miles. Next, as to the depth of water: If a standard of 24 feet at low-water was assumed, it would be found that in the Mutla there were no shoals; whereas in the Hooghly there were six, of a length in the aggregate of upwards of 14 miles, with a low-water depth of from 15 feet to 18 feet only. To give a standard depth of 30 feet at low-water, the Mutla would require deepening at four places to an extent varying from zero to 6 feet; whilst in the Hooghly the length to be deepened would be nearly 26 miles, and the depth to be excavated from zero to 15 feet. Again, in the Hooghly, the lowermost shoal was 63 miles from the uppermost, whereas, in the Mutla, taking even the 30 feet standard, the shoals, which were much less in extent, were all contained within a distance of 30 miles; or if the first and last, which were inconsiderable and might easily be removed, were neglected, then the only existing shoal would be comprised in a distance of 5¾ miles. It might be stated generally that, whereas a ship drawing 24 feet could only get to sea from Calcutta by the aid of steam, and under the most favourable circumstances, in three to four days, or during the south-west monsoon in five days, the same vessel could at all times get to sea from the head of the Mutla, in from eight to ten hours. By the adoption of the Mutla it was believed that two days could be saved in the time of the postal and passenger service between this country and Calcutta. In the author's report on the Calcutta and South Eastern Railway (1857), he entered fully into the comparative charges of the two ports, and the result showed a saving of £587 10*s.* on each voyage of a a ship of 1000 tons, in favour of the Mutla, or about 11*s.* 9*d.* a ton.

With regard to the engineering points involved in the comparison of the two rivers, it would have been remarked that both ran through a precisely similar country, both were remarkably alike in their courses, and both were subject to the same tides; yet one was dangerous and difficult, whilst the other was safe and convenient for navigation. Whence did this difference arise, and could it be remedied? The great physical distinction was, that in the Hooghly there was a vast, though greatly varying, supply of fresh water, acting simultaneously with the tidal flow; whereas in the Mutla there was tidal water alone, and not only that which filled its own bed every twenty-five hours, but a vast body which passed through it, and flowed into and ebbed from the great reservoir channels of the Biddiadhurree and the Attara Banka and their branches at the head, and other Sunderbund creeks. This was the distinction in the conditions to which, in the author's opinion, were due the differences in their state as navigable channels. The comparison of these two rivers appeared to him decisive as to the value of tidal water alone *versus* fresh water and tidal scour combined. By tidal scour alone there was a deep and unchanging channel free from bars and shifting sands. By the combined action of fresh water and tidal scour there were shoals, shifting sands, variable channels, and a gradual, and it

NOTES OF THE MONTH.

Society of Arts.—The first ordinary meeting of the hundred and eighth session was held on the 20th ult. Sir Thomas Phillips, F.G.S., chairman of the council, presided, and delivered an address, in the course of which he said that as the International Exhibition buildings were susceptible of much decoration, it was thought desirable to originate a subscription for the purpose of making experiments in the employment of Mosaics on the external walls of the front in Cromwell-road. The subscription was begun by Earl Granville; and, should the Mosaics be successful, they would give to the buildings a character new in this country, especially suitable to the climate, and hardly to be found on any buildings north of the Alps.

Wellingborough Church.—This edifice, which has lately been restored, was re-opened on the 19th ult. The church was temporarily repaired in 1843, but in 1850 the work of restoration was commenced under the advice and direction of Mr. G. Gilbert Scott. The chancel and aisles were then reseated with open oak seats, and the beautiful oak screen and the stonework of the pillars, arches, and windows were thoroughly restored. The galleries were also removed from the aisles. This part of the work of restoration cost £1250. In the course of last year it was resolved to finish this work, and the restoration of the nave and aisles has now been completed. The plaster ceiling of the nave has been replaced by a new panelled roof; two galleries at the west end of the nave have been removed, and the whole nave and aisles re-seated with oak to correspond with the chancel. The tower arch has been restored and thrown open, and the woodwork of the western wheel window has been removed and replaced by stone tracery, and filled with stained glass. All the other windows in the building, including the great eastern window (which will be one of the finest in the county, have been restored and re-glazed. Many minor improvements have also been made. Owing to the removal of the galleries the actual number of the seats has been greatly diminished, but the new open oak seats are very much superior in comfort and accommodation. This remaining portion of the work has been executed at a cost of £1500.

Society for the Encouragement of the Fine Arts.—The opening meeting of the Fourth Session of this Society was held at 9, Conduit-street, Regent-street, on the evening of the 28th ult., when a lecture on "Art Education" was delivered by Mr. James Dafforne. We have already laid before our readers the objects and aims of this valuable Society, and recorded its progress from time to time. We are gratified to learn that the prospects are most satisfactory, the number of members having considerably increased since this time last year. The course of lectures now commenced includes music and the drama, which will be treated by Dr. Chr. Dresser, Mr. John Leighton, F.S.A., Mr. F. Y. Hurlstone, Mr. H. Ottley, Mr. A. Gilbert, Mr. J. A. Heraud, Mr. G. Montague Davis, B.A., the Rev. Hugh Hutton, and others. It is the intention of the council, in addition to the ordinary *conversazione*, to give a special entertainment in honour of distinguished Continental artists who will visit this country in connection with the International Exhibition. Mr. Dafforne's lecture set forth the want of art-education in this country. He argued against the absurdity of neglecting to teach a child to draw, because it might not have exhibited a special taste for art —a reason which would never be admitted as against any other branch of education. The lecture was followed by an interesting discussion. The subject of the next address will be "Decorative Art," and the lecturer will be Dr. Dresser.

St. George's, Shropshire.—The foundation stone of a memorial church to the late Duke of Sotherland, K.G., was recently laid in the district of St. George's, formerly Pain's-lane, Shropshire. The church is designed to accommodate 700 persons. It is to be rectangular in plan, with a chancel 40 feet by 20 feet; the nave, with side aisles and clerestory, 90 by 50 feet. At present, a tower, about 40 feet high, will be erected at one end; but if the funds admit, it is intended to raise upon it a spire, 150 feet high. The style of the building will be Early English. The cost, without the spire, will be £4000, but including the spire, £5000. The architect is Mr. G. E. Street. The contractor is Mr. Horsman, of Wolverhampton.

Accidents on French Railways.—The following appears in the *Révue Contemporaine*:—"On the Northern, Strasburg, Western, Orleans, and Mediterranean lines of railway, 2130 trains run every day, and the distance performed is altogether 192,000 kilometres ($\frac{5}{8}$ths of a mile each), making a total of 777,450 trains, and more than seventy millions of kilometres in the year. The number of passengers conveyed on those lines in the years from 1850 to 1860 was about 310 millions, and during that period the loss of life by accidents was forty-four, or one out of seven millions. Does there exist a human undertaking where material forces are used in the midst of difficult circumstances, and with the co-operation of such a considerable number of men, which would engage not to make a greater number of victims? The above figures, taken from official sources, have an eloquence which cannot be easily weakened, and against which affirmations too lightly brought cannot prevail. What additional force do not these calculations acquire when they are compared with the number of carriage accidents which take place in one year in the public thoroughfares of Paris alone? In 1860, for instance, the official statistics inform us that the casualties of that kind amounted to 920, which occasioned the death of thirty persons, and serious injuries to 579 others. Thus the circulation of carriages in Paris has led to almost as many violent deaths in one year as the circulation on the French railways in ten years."

Wall Paintings.—The *Literary Gazette* announces that the painter Leys has received a commission to execute, in a hall of the Hôtel de Ville at Antwerp, a series of wall paintings, for which he is to receive 200,000 francs.

Pompeii.—A letter from Dr. Bruce was read at the last meeting of the Society of Antiquaries, at Newcastle, from which we extract the following:—"The day after my arrival here found me on my way to Pompeii. * * I at once understood the peculiar construction of the Pompeian houses. The restored house in the Crystal Palace gives you an idea of coldness and gloom. At Pompeii itself, smarting as I did at the end of October under the heat and glare of the sun, I could understand how precious an open roof, and shady corner, and dripping fountains would be in July. * * It has been an ill-built city. The walls of the houses are like those of London. The masonry of our wall is much superior to most of that at Pompeii. The buildings consist of tiles, lava, volcanic tufa, and organic tufa, or what we would call petrified moss. It is astonishing how largely this organic tufa, which we are familiar with in the Roman buildings in the north of England, enters into the composition of its buildings. The walls of the city have been originally made of pieces of lava not much larger than a good-sized fist. It has, however, been repaired at two subsequent periods with large-sized and well-squared blocks of organic tufa and travertine. The fountains in Pompeii are numerous, each being provided with a cistern, something like that at the north gate of Borcovicus. I measured the ruts in the streets. From the centre of the one to the centre of the other is 4 ft. 7 in. I measured one street, which was 7 ft. 3 in. wide, and another, which was 6 ft. 4 in. We must not be surprised that the streets in our stations are so narrow. I studied the public baths with care: they are very complete and interesting. The place where the coppers were placed is clearly marked; and you can trace the water in its course, and follow the hot air from the furnaces, under the floors, and up the sides of the rooms. * * One day we went to Puzzuoli (the ancient Puteoli), where the Apostle Paul landed for Malta on his way to Rome. We trod upon the very stones of the Roman way which he traversed. The amphitheatre here is very complete, especially in the underground arrangements. The Temple of Neptune, where Pompey sacrificed before the battle of Actium, is still to be seen. The Temple of Serapis is a beautiful ruin; it has been submerged by the sinking of the coast, and again raised by volcanic action. The pillars, washed by the sea level, and eaten by the pholas below this line, prove this. I have photographic views which clearly exhibit this striking fact."

TO CORRESPONDENTS.

Veritas.—It is impossible to transfer to the pages of this Journal the discussion which Veritas commenced in the columns of a contemporary. It is usual for communications to the Editor to be authenticated by the inclosure of the writer's name and address.

END OF VOLUME XXIV.

INDEX TO VOLUME XXIV.—1861.

A.

Abbey, Chertsey, 186
—— St. Albans, restorations at 256
Abergele, independent chapel at, 166
Abutments, new rule for determining the thickness of, 102
Academy, royal, architecture at, 155, 211
—— royal Hibernian, 90
Accidents on railways, 212
—— on French railways, 376
Acoustics, T. R. Smith on, 2, 46
—— (rev.) 241
Adie on the gold-disk steam or vacuum gauge, 89
Agricultural hall, Islington, 281
Alarms, fire and railway, Siemens on, 308
Alexandria, catacombs at, Donaldson on, 101
Alluvial districts, iron bridges in, Kennedy on, 251
Ancient buildings, Street on restoration of, 199
—— remains in Ringmore church, 90
Ancona to Bologna, railway from, 98
Angle between the chord and tangent of any arc, rule for finding, 314
Antiquaries, society of, 376
Archæological association, 90
—— institute, 250
Arches and columns, iron, Sheilds on, 296
Architect, board of works, election of, 122
Architects' charges, 59
—— Royal Institute of British, 88, 161, 186, 355
Architecture, analysis of ancient domestic, (rev.) 58, 348
—— dark ages of, Seddon on, 259, 259
—— Fellah-arab, in Egypt, Donaldson on, 69
—— of London, Hope on, 180
—— mediæval, study-book of, King, 149
—— at the Royal Academy, 155, 211
—— colour as applied to, Smirke on, 65, 93
—— consistency in, Smirke on, 103
Architectural accessories of monumental sculpture, Cockerell on, 333
—— association, 368
—— competitions, 91, 167, 208; M. Daly's pamphlet on, 222
—— drawing, 18

ARCHITECTURAL ERECTIONS (NEW)—
  Chapel, Hampstead, Johnson, 219
  —— independent, Abergele, Smith, 166
  —— New Wellington college, Scott, 251
  Church, Baldwin's-gardens, London, Butterfield, 96
  Church, German, Islington, Constantine, 186
  —— Hanger-lane, Stamford-hill, Talbot Bury, 96
  —— Higham, Scott, 232
  —— Howsham, Yorkshire, Street, 70
  —— Ince-in-Mackerfield, Lancashire, Paley, 150
  —— St. Andrew's, Leicester, 282
  —— St. George's, Shropshire, Street, 376
  —— St. James the Less, Westminster, Street, 96
  —— St. Martin on the Hill, Scarborough, Bodley, 347
  —— St. Mary, Hornsey rise, Gough, 96
  —— St. Paul, Hoddlesden, Paley, 326
  —— SS. Peter and Paul, Cork, Pugin and Ashlin, 90
  —— St. Philip and St. James, Oxford, Street, 281

Architectural erections (continued)—
  Drinking fountain, Tolmie, 122
  Exhibition building, international, 1862, Fowke, 99, 344
  Hall, agricultural, Islington, 281
  —— Ashwicke, Gloucestershire, Colling, 315
  Library, Vaughan, Harrow, Scott, 250
  Manufactory, Greenway's, Birmingham, 375
  Post offices, new district, 153

Architectural examination, list of works recommended to candidates, 280
—— exhibition, 123, 151, 158
—— students, proposed examinations for, 362
—— photographic exhibition, 37
—— profession, examinations for, 57
—— publication society, 226
—— study and progress, Blomfield on, 368
Arsenic in paperhangings, Letheby on, 18
Art, romanesque, Waring on, 114, 139
Arts, exhibition of institution of the fine, 99
—— society for encouragement of fine, 376
—— society of, 127, 376
Artists, society of British, 146
Ascot, new hotel, 250
Ashpitel on origin and development of use of crypts in Christian churches 9
Ashton-under-Lyne and Dukinfield mechanics' institution, 58
Ashwicke hall, Gloucestershire, 315
Association, architectural, 368
—— British, 186, 250, 286, 327
—— for prevention of steam boiler explosions, 218
Atherton on freight as affected by differences in the dynamic properties of steamships, 304
Austin, Henry, the late, 346
Austrian engineers' union, 186
Ayton on disengaging catch for miners' safety cage, 74
Axles, steel railway, 281

B.

Bakewell, new theory of the figure of the earth, 232, 313, 315, 345
Bank of England, 154
Bardwell's design for Thames embankment, 190
Barlow on the Niagara railway suspension bridge (rev.) 53
Barometrical column, disturbances of, 31
Barry, Sir C., statue to the late, 282
Bathometer, Siemens on, 329
Bath market improvement, 282
Bayeux and Chichester cathedrals, Burnell on operations at, 235
Bazalgette's design for Thames embankment, 188
Beacons, floating, Stoney on construction of, 113, 146
Beams, strength of, Cooper on, 153
Bell on colour on statues, 168
—— on colour round statues, 205
Bells, clocks, and watches. Denison on, 342
Bengal railway, eastern, 281
Bernard on healthy moral homes (rev.) 217
Bessemer on manufacture of steel, 267
Bidder, Harrison, and Stephenson's design for Thames embankment, 189
Bidder on national defences, 172
Bird's design for Thames embankment, 192
Birkenhead, new graving dock, 90
Birmingham, Greenway's manufactory, 375
Blackfriars, proposed new bridge, 282
Blackwell on a new process of open coking, 57
Blast furnaces, Cochrane on waste gases from, 14
Blasts at Holyhead, Robertson on, 38, 75
Blomfield on architectural study and progress, 368
—— on the arrangement of churches, 41
Boiler explosions, association for prevention of, 218
—— action of steam in relation to, 133
Bologna and Ancona railway, 98
Bourne on the steam engine in its application to mines, mills, &c. (rev.) 243
Bow's level, 336
Braithwaite on the river Wandle, 107
Bridge, Blackfriars, proposed new, 282
—— construction, cast and wrought iron, Humber on (rev.) 278, 312
—— iron girder, Boston and Worcester railroad, U.S. 209
—— Köpcke on the construction of a rigid suspension, 6
—— Lendal, York, 155
—— new, at Lambeth, 283
—— Niagara railway suspension, Barlow on (rev.) 53
—— Roebling on (rev.) 118
—— railway, across Rhine, 122
Bridges and girders, wrought iron, effect o vibratory action upon, Rankine on, 327
—— cast steel, 96
—— railway, iron, in alluvial districts, Kennedy on, 251
—— statics of, 1, 59, 163, 223, 315, 347
—— suspended girder, Rankine on, 4
—— suspension, deflection of, Cox on, 207
—— suspension girder, 35
—— suspension girder, Latham on, 126
British architects, royal institute of, 88, 161, 186
—— association for the advancement of science, 180, 250, 286, 327
Bruce on Pompeii, 376
Building for international exhibition of 1862, 199, 344
—— materials, inventions and patents, architectural exhibition, 151, 153
Buildings, public, acoustics of, Smith on, 241
—— ancient, Chichester cathedral and other, Hills on, 266
—— ancient, restoration of, Street on 199
—— improvements in warming of, 184
Burford's panorama, 122
Burges on architectural drawing, 18
Burn on the construction of horse railways for branch lines and street traffic (rev.) 81
Burnell on operations at Bayeux and Chichester Cathedrals, 235
—— on condition of water supply of London, 71
Bury St. Edmund's corn exchange, 32
Byrne on pressure of steam on cylinder covers and other disks, 353

C.

Cable, submarine, Hall and Wells', 8
Cables, submarine, Preece on the maintenance and durability of, in shallow waters, 25, 141
—— telegraphic, india rubber and gutta percha, 186
Calcutta, Dalhousie institute, 58, 186
Canal, the Suez, 101
Candidates for architectural examination, list of works recommended to, 280
Cargill on method of finding centre of gravity of girder, 121
Cargill's short rule for finding angle contained between chord and tangent of any arc, 314
Carriages, railway, warming, 90
Cast steel bridges, 96
Catacombs at Alexandria, Donaldson on, 101
Catch, disengaging, for miners' safety cage, Ayton on, 174
Cathedral of nineteenth century, Hope (rev.) 173, 215
Cathedrals—Bayeux and Chichester, 235; Chichester, restoration of, 117, 247, 266, 281; Ely, 314; Lichfield, 4, 315; Llandaff, 251; Worcester, 280
Channel railway to connect England and France, Chalmers on (rev.) 370
Chapel, Hampstead, 219
—— independent, Abergele, 166
—— royal in the Savoy, London, 154
Charges, architects', 59
Chertsey abbey, 186
Chester, St. John's church, 154
Chichester and Bayeux cathedrals, operations at, Burnell on, 235
—— cathedral, restoration of, 117, 247, 281
—— the cathedral and other ancient buildings, Hills on, 247, 266
Chimneys, new system of arranging, 218
Church and conventual arrangements, Walcott on, 22, 271

CHURCHES—
  Baldwin's-gardens, Gray's-inn-lane, London, 96
  German, Islington, new, 186
  Hauger Lane, Stamford Hill, London, 96
  Ince-in-Mackerfield, 150
  Namptwich, Cheshire, 359
  National Scotch, Regent Square, London, restoration of, 102
  Notre Dame, 122
  Outwell, Norfolk, restoration of, 150
  Stoughton, Leicestershire, 282
  St. Andrew's church, Leicester, 282
  St. George's, Shropshire, 376
  St. James the Less, Upper Garden Street, Westminster, 96
  St. John's, Chester, 154
  St. John the Evangelist, Howsham, 70
  St. Martin on the Hill, Scarborough, 347
  St. Mary, Hornsey Rise, 96
  St. Paul, Hoddlesden, 226
  St. Peter, Higham, 232
  St. Peter and St. Paul, Cork, 90
  St. Philip and St. James, Oxford, 281
  Wellingborough, 376

Churches, Blomfield, on the arrangement of, 41
—— new, in London, 96
Clocks, watches, and bells, Denison on (rev.), 342
Coal, petroleum, &c., Gesner on (rev.), 180
Cochrane on method of taking waste gases from blast furnaces, 14
Cockerell on architectural accessories of monumental sculpture, 333
Coffer-dam, Hunt on new portable, 45
Coking, open, Blackwell on new process of, 57
College, King's, professorship of arts of construction, 362
—— new Wellington, 251
Collieries and colliers, Fowler on (rev.), 278
Colling's Gothic ornaments (rev.), 31

Collins on electro block printing, 27
Colour as applied to architecture, Smirke on, 65, 93
Colour on statues, Bell on, 168
—— round statues, Bell on, 205
Column, barometrical, disturbances of, 31
Columns and arches, iron, and iron construction, Shields on, 296

COMPETITIONS—
  Corn exchange, Bury St. Edmund's, 32
  Dalhousie institute, Calcutta, 58, 186
  Hotel, Saltburn-by-the-Sea, 32
  Laying out land for building, Plymouth, 58
  Mechanics' institution, Ashton-under-Lyne and Dukinfield, 58
  Thames embankment, 122
  Town hall and public offices, Kingston-upon-Hull, 122

Competition designs for new Houses of Parliament, Sydney, 221
Competitions, architectural, 91, 166, 208
—— architectural, Daly's pamphlet on, 222
Concrete, machine for making, 346
Conder on new theory of figure of the earth, 278
Construction of floating beacons, Stoney on, 113
Construction, railway, rudimentary instructions on (rev.) 177
Coombs' design for Thames embankment, 190
Cooper on strength of beam fixed at both ends, 153
Continental publications, 86, 92, 148, 218, 246, 279, 284, 349
Corn exchange, Bury St. Edmunds, 32
Coupling, new safety, Markham on, 198
Covent Garden approach, subway, 130
Cox on deflection of suspension bridges, 207
—— on shearing strains of deflected girders, 249, 279
Cronstadt, the new graving slip, 32
Crypts, Ashpitel on the origin and development of their use in christian churches, 9
Cubitt, Sir W., the late, 343
Currents, telluric, 282
Curves on railways and other public works, tables for, Olver (rev.) 274
Cylinder covers and other disks, pressure of steam on, Byrne on, 353

D.

Dalhousie institute, Calcutta, 186
Daly's pamphlet on architectural competitions, 222
Dark ages of architecture, Seddon on, 259
Decorative and industrial art exhibition, Edinburgh, 250
Defences, national, Bidder on, 172
—— the national, 362
Deflected girders, shearing strains of, Cox on, 249, 279
Denison on clocks, watches, and bells, 342
Design, consistency in style of, Smirke on, 131
Designs for Thames embankment, 187
Dircks on perpetuum mobile (rev.) 245
Discoveries at Suez, 346
Disengaging catch for miners' safety cage, Ayton on, 74
District post-offices, new, 153
Dock, dry, reclamation embankment for Leith, Robertson on, 162
—— improvements at Grangemouth, Milne on, 86
—— new graving, Birkenhead, 90
Dollman and Jobbins' ancient domestic architecture (rev.) 53, 343
Donaldson on the catacombs at Alexandria, 161
Donaldson's description of Mariette's excavations at Gizeh and Saccara, 77
Donaldson on Fellah-arab architecture in Egypt, 69
Doull, design for Thames embankment, 190
Drawing architectural, Burges on, 18
Drinking fountains, 122
Dry dock, Leith, reclamation embankment for dry dock, Robertson on, 162
Dwellings and hospitals, ventilation of, 219, 324
Dwellings for working men, Leeds, 154

E.

Earth, new theory of the figure of, Bakewell, 232, 278, 313, 315, 345
Eastern Bengal railway, 281
Ebonite, or hard india-rubber, Silver on, 330
Edinburgh, exhibition of industrial and decorative art, 250
Egypt, Fellah-arab architecture in, Donaldson on, 69
Electric light, 138
—— resistance thermometer, Siemens on, 332
Electro-block printing, Collins on, 27
Elements of mechanism, by Goodeve (rev.) 28
Ely cathedral, 314
Ely Place, Holborn, history and description of, 5, 38
Embankment, Thames, report of commissioners, 220
Embankment, Thames and railway communication in London, Lane on (rev.) 118
Embankment, Thames, 122, 152, 157, 187, 220

EMBANKMENT, THAMES, DESIGN FOR—
  Bardwell, 190
  Bazalgette, 188
  Bidder, Harrison, and Stephenson, 189
  Bird, 192
  Coombs, 190
  Doull, 190
  Fowler, Fulton, and Hemans, 189
  Haggett, 192
  Moorsom, 191
  Newton, 191
  Page, 187
  Rendel, 184
  Sewell, 191
  Shields, 192
  Sich, 189
  Stanford, 190
  Thompson, 191
  Turner, 192
  Vetch, 192
  Weller, 191

Engine, steam, in its application to mines, mills, &c., Bourne on (rev.) 243
Engineers' manual of the hydrometer, Swift (rev.) 176
Engineers, mechanical institution of, 264
—— union, Austrian, 186
Engineering, gas, Laidlaw on, 96

ENGINEERING ERECTIONS, NEW—
  Bridge, Lendal, York, Dredge, 155
  —— iron girder, Boston and Worcester railroad, U. S., 209
  —— Lambeth, new, P. W. Barlow, 283
  —— railway, over Rhine, 122
  Embankment, reclamation, for dry dock, Leith, 162
  Graving slip, Cronstradt, H. Grissell, 32
  Railway, floating, across Forth and Tay, 171
  Railway incline, Thul Ghaut, G. I. P. railway, 135
England, bank of, 154
English cathedral of nineteenth century, Hope (rev.) 173
Examination, architectural, list of works recommended to candidates, 280
Examinations for the architectural profession, 57
—— proposed, for architectural students, 362
Excavations, Mariette's, at Gizeh and Sacara, Donaldson on, 77
Exhibition of 1862, inventors and, 154

EXHIBITIONS—
  Architectural, 123, 151, 158
  —— photographic, 37
  British artists, society of, 148
  French and Flemish pictures, 122
  French industrial, 250
  Industrial and decorative art, Edinburgh, 250
  Institution of the fine arts, 99
  International, of 1862—90, 95, 99, 150, 344
  Inventions at society of arts, 127
  Photographic society, 69
  Society of female artists, 88

Experiments on the gauging of water, Thompson on, 360
Explosions, boiler, action of steam in relation to, 138
—— steam boiler, association for prevention of, 218

F.

Fairbairn on effects of vibratory action upon wrought-iron bridges and girders, 327
—— on iron, its history, properties, &c., 177
—— on mills and mill work (rev.) 274, 341
Fellah-arab architecture in Egypt, Donaldson on, 69
Female artists, society of, 88
Fences, wooden, preservation of, 90
Ferrey's recollections of Pugin (rev.) 310
Figure of the earth, new theory, Bakewell on, 232, 278, 313, 315, 345
Fine arts, institution of, exhibition, 99
—— society for encouragement of, 376
Fire extinguished by steam, 141
Fire and railway alarms, Siemens on, 308
Floating beacons, Stoney on, 113, 146
—— railway across Forth and Tay, Hall on, 171
—— of ship Queen Victoria, 90
Foreign office, new, 122
—— publications, 86, 92, 148, 218, 246, 279, 284, 349
Formula, Wiesbach's, for finding head due to the friction of water in pipes, 375
Fountains, drinking, 122
Fowler, on collieries and colliers (rev.) 278
Fowler, Fulton, and Heman's design for Thames embankment, 189
Fox on iron permanent way, 111
Franklin, Sir John, monument, 121
Freight, as affected by differences in dynamic properties of steam ships, Atherton, on, 304
French industrial exhibitions, 250
—— railways, accidents in, 376
—— railways, statistics of, 153
Fresco painting and stone, preservation of, 40

G.

Gas engineering, Laidlaw on, 96
—— lighting steamers with, 122
—— supply of London, 257
—— works, small, for private residences, 281
Gases, waste, taking off from blast furnaces, Cochrane, 14
Gauge, gold-disk, steam or vacuum, Adie on, 89
Gauging of water, experiments on, Thompson on, 360
Gearing, skew-bevel, Rankine on, 322
German church, new, Islington, 186
—— ocean, Murray on, 146, 202
Gesner on coal, petroleum, &c. (rev.) 180
Giffard's injector, 186
Gill on the thermo-dynamics of elastic fluids, (rev.) 55
Girder, method of finding centre of gravity of, Cargill on, 121
Girder bridge, iron, Boston and Worcester railroad, U.S. 209
Girder bridges, suspended, Rankine on, 4
Girder bridges, suspension, 35
—— Latham on, 126
Girders, deflected, shearing strains of, Cox on, 249, 279
Girders and bridges, wrought-iron, effect of vibratory action upon, Rankine on, 327
Gold-disk steam or vacuum gauge, Adie on, 89
Goodeve on the elements of mechanism, (rev.) 28
Gothic ornaments, Colling (rev.) 31
Grangemouth docks, improvements at, 86
Graving dock, new, Birkenhead, 90
Graving slip, new, Cronstadt, 32
Greenway's manufactory, Birmingham, 375

H.

Haggett's design for Thames embankment, 192
Hall and Wells' submarine cable, 8
Hall, agricultural, Islington, 281
—— Ashwicke, Gloucestershire, 316
—— music, proposed, South Kensington, 354
Hall on floating railway across Forth and Tay, 171
Hammers, steam, Peacock on, 240
Hampstead, chapel, 219
Harrow, Vaughan library at, 250
Healthy moral homes, Bernard on (rev.) 217
Heat, C. Wye Williams on (rev.) 29, 82
Hibernian academy, royal, 90
Higham, St. Peter's church, 232
Hills on Chichester cathedral, &c. 247, 266
History and description of Ely place, Holborn, 5, 33
History of St. Mary's Abbey, Melrose, &c., Wade on (rev.) 372
Hoddlesden, St. Paul's church, 226
Holland's office and cabin companion (rev.) 373
Holyhead, large blasts at, Robertson on, 88, 75
Homes, healthy moral for agricultural labourers, Bernard on (rev.) 217
Hooghly and the Mutla, Longridge on, 373
Hooper on the pier at Southport, 113
Hope on the architecture of London, 180
—— on the English cathedral of the nineteenth century (rev.) 170, 215
Horse railways for branch lines and street traffic, Burn on (rev.) 81
Hospitals and dwellings, ventilation of, 219, 324
Hotel, new, Ascot, 250
Hotel, Saltburn-by-the-sea, 32
Houses of parliament, the new, 186
—— of parliament, stone of, 122, 315
—— of parliament, Sydney, competition designs for, 221
Howsham, church of St. John, 70
Humber on cast and wrought iron bridge construction (rev.) 278, 312
Hunt on a new portable coffer-dam, 45

I.

Improvement, Bath market, 292
Improvements in docks at Grangemouth, Milne on, 86
—— in warming of buildings, 184
Ince-in-Mackerfield church, 150
Incline, the Thul Ghaut, on great Indian Peninsular railway, 135
Independent chapel, Abergele, 166
India museum, Whitehall, 250
—— progress of, 284
—— railways in, 281
India-rubber and gutta percha telegraphic cables, 186
—— hard, Silver on, 330
Indicator, gradient, and level, Bow's, 336
Industrial and decorative art, exhibition of, at Edinburgh, 250
Injector, Giffard's, 186
Institute, archæological, 250
—— of British architects, royal, 88, 161, 186, 355
—— Dalhousie, Calcutta, 58, 186
Institution of the fine arts, exhibition, 99
Instruments on the earth's surface, "direct" magnetic effect of sun or moon on, Stoney on, 333
Intercourse, metropolitan, 31
International exhibition of 1862 and the metal manufactures, 150
—— exhibition of 1862, 90, 95, 99, 150, 244
Inventions, exhibition of, at society of arts, 127
Inventions, patents, and building materials, architectural exhibition, 151, 158
—— property in, Webster on, 331
Inventors and the international exhibition of 1862, 154
Iron bridge construction, Humber on (rev.) 278, 312
Iron construction, and strength of iron columns and arches, Shields on, 296
Iron girder bridge, Boston and Worcester rairoad, U. S., 209
Iron, history, properties, &c., Fairbairn on, (rev.) 177
Iron permanent way, Fox on, 111
Iron pipes, preserving, 122
Iron railway bridges in alluvial districts, Kennedy on, 251
Ironwork, strains on structures of, Shields (rev.) 119
Islington, agricultural hall, 281
—— new German church, 186

K.

Kennedy on iron railway bridges in alluvial districts, 251
King's college, professorship of arts of construction, 362
Kingston-upon-Hull town-hall, 122
Köpcke on the construction of a rigid suspension-bridge, 6

L.

Laidlaw on gas engineering, 96
Lambeth, new bridge at, 283
Lane on railway communication in London, and Thames embankment (rev.) 118
Latham on suspension girder bridges, 126
Lawrie on the treatment of steam for the development of power, 20
Laws, patent, 322
Laws, U.S. patent, 184
Leeds, dwellings for working men, 154
Leicester, St. Andrew's church, 282
Leith dry dock, Robertson on, 162
Lendal bridge, 155
Letheby on arsenic in paperhangings, 13
Level, Bow's, 336
Library, Vaughan, at Harrow, 250
Lichfield cathedral, restoration of, 4, 315
Light, electric, 138
Llandaff cathedral, 251
London, architecture of, Hope on, 180
—— gas supply, 257
Longridge on the Hooghly and the Mutla, 373
Lubricator, 82
Luther monument at Worms, 90

M.

Machine for making concrete, 346
Machine, new tunnelling, 346
Magnetic effect, direct, of sun or moon on instruments on the earth's surface, 333
Manual of the hydrometer (rev.) 176
Manufactory, Greenway's, Birmingham, 375

Manufacture of steel, Bessemer on, 267
Mariette's excavations at Gizeh and Saccara, Donaldson on, 77
Market improvements, Bath, 282
Markham on new safety coupling, 198
Masson on new system of arranging chimneys, 218
Materials, building, at the architectural exhibition, 151, 158
Mechanism, elements of, Goodeve on (rev.) 28
Mechanical engineers, institution of, 204
Mechanics' institution, Ashton-under-Lyne 58
Mediæval architecture and art, study-book of, King, 149
Memoir of Henry Austin, 346
—— of Sir W. Cubitt, 348
Metal manufactures and exhibition of 1862, 150
Metropolitan intercourse, 31
Metropolitan railway, 28
Mills and millwork, Fairbairn on (rev. 274, 341
Milne on dock improvements at Grangemouth, 86
Mines, mills, &c., steam engine in its application to, Bourne on (rev.) 243
Minster, York, 270
Mobile, perpetuum, Dircks on, 245
Monument, Luther, at Worms, 90
Monument, Sir John Franklin, 121
Moorsom, design for Thames embankment, 191
Murray on building of ships and steamships (rev.) 243
Murray on the North Sea, 146, 202
Museum, India, Whitehall, 250
Music hall, proposed, South Kensington, 354

N.

Namptwich church, Cheshire, restoration of, 359
National defences, the, 362
National defences, Bidder on, 172
National Scotch Church, Regent-square, London, restoration of, 102
New churches, 96
Newton's design for Thames embankment, 191
Niagara railway suspension bridge, Barlow on (rev.) 53
Niagara railway suspension bridge, Roebling on (rev.) 118
North Sea, Murray on, 146, 202
Notre Dame, 122

O.

Office and cabin companion, Holland on (rev.) 373
Office, new foreign, 122
Olver's tables for setting out curves on railways, &c., 274
Ornaments, Colling's Gothic (rev.) 31
Outwell church, 150
Oxford, new church, St. Philip and St. James, 281

P.

Page, design for Thames embankment, 187
Page, design for new bridge, Blackfriars, 282
Paintings, wall, 376
Palace of Westminster, decay of stone of, report of committee on, 337
Panorama, Burford's, 122
Paperhangings, arsenic in, Letheby on, 18
Parliament, the new houses of, 186
Parliament houses, stone of, 122, 315
Parliament houses, Sydney, competition designs for, 221
Patent law, United States, 184
Patent laws, 322
Patent tribunals, Spence on, 297
Patents, inventions, and building materials at the architectural exhibition, 151, 158
Peacock on steam hammers, 240
Permanent way, iron, Fox on, 111
Perpetuum mobile, Dircks on (rev.) 245
Petit on the revival of styles, 195, 227
Petroleum, coal, &c., Gesner on (rev.) 180
Philbrick on iron girder bridge, Boston and Worcester railroad, U. S., 209
Photographic exhibition, architectural, 37
Photographic society's exhibition, 69
Photo-zincography, 154
Pier at Southport, Hooper on, 113
Pictures, French and Flemish, exhibition of, 122
Pipes, iron, preservation of, 122
Plans for building land, Plymouth, 58
Pompeii, Bruce on, 376
Post offices, new district, 153
Preece on the maintenance and durability of submarine cables in shallow waters, 25, 141
Preservation of stone and fresco painting, 38
Preservation of stone, 37, 65
Preservation of timber, 282
Preservation of wooden fences, 90
Printing, electro-block, Collins on, 27
Private residences, gas works for, 281
Professorship of arts of construction, King's College, 362
Progress of India, 284
Progressive screw as a propeller in navigation, Rêvy on (rev.) 85
Property in inventions, Webster on, 321
Propulsion, screw, Walker on (rev.) 121, 245
Public buildings, acoustics of, Smith on (rev.) 241
Publication society, architectural, 226
Publications, foreign, 36, 92, 148, 218, 246, 279, 285, 347
Pugin, recollections of, Ferrey's (rev.) 310

R.

Railway axles, steel, 281
Railway from Ancona to Bologna, 98
Railway bridge over Rhine, 122
Railway bridges, iron, in alluvial districts, Kennedy on, 251
Railway carriages, warming of, 90
Railway, channel, to connect England and France, Chalmers on (rev.) 370
Railway communication in London, and Thames embankment, Lane on (rev.) 118
Railway construction, rudimentary instructions, Weale (rev.) 177
Railway, Eastern Bengal, 281
Railway and fire alarms, Siemens on, 308
Railway, floating, across Forth and Tay, 171
Railway, great Indian Peninsular, Thul Ghaut incline, 185
Railway, the metropolitan, 28
Railway, street, Westminster, 154
Railway waggons, new coupling for, 198
Railways, accidents on, 212
Railways, &c. Olver's tables for curves on, (rev.) 274
Railways, French, statistics of, 153
Railways, French, accidents on, 376
Railways, high speeds on, 349
Railways, horse, Burn on (rev.) 81
Railways in India, 281
Rankine on effect of vibratory action upon wrought iron girders and bridges, 327
Rankine on resistance of ships, 294
Rankine on skew-bevel gearing, 322
Rankine on suspended girder bridges, 4
Recollections of A. W. Pugin, Ferrey (rev.) 310
Remains, ancient, in Ringmore church, 90
Remains, Roman, 186
Rendel's design for Thames embankment, 189
Report of committee on decay of stone of new palace, Westminster, 337
Report of commissioners on Thames embankment, 220
Resistance of ships, Rankine on, 294
Restoration of ancient buildings, Street on, 199

Restorations—
  Chicester cathedral, 117
  Lichfield cathedral, 4, 315
  Llandaff cathedral, 251
  Namptwich church, Cheshire, 359
  National Scotch church, Regent-square, London, 102
  Notre Dame, Paris, 122
  Outwell church, Norfolk, 150
  Stoughton church, Leicestershire, 282
  St. Alban's abbey, 256
  St. John's church, Chester, 154
  Wellingborough church, 376
  Worcester cathedral, 260

Reviews—
  Acoustics of public buildings, Smith, 241
  Analysis of ancient domestic architecture, Dollman and Jobbins, 53, 343
  Bridge construction, cast and wrought iron, Humber, 278, 313
  Channel railway to connect England and France, Chalmers, 370
  Church and conventual arrangement, Walcott, 271
  Clocks, watches, and bells, appendix to fourth edition, Denison, 342
  Collieries and colliers, Fowler, 278
  Colling's Gothic ornaments, 31
  Curves on railways, &c., tables for, Olver, 274
  Economy of steam-power on common roads, Young, 86
  Elements of mechanism, Goodeve, 28

Reviews (continued)—
  Engineer's manual of the hydrometer, Swift, 176
  English cathedral of the nineteenth century, Hope, 173, 215
  Essay on the thermo-dynamics of elastic fluids, Gill, 55
  Healthy moral homes for agricultural labourers, Bernard, 217
  Heat in its relation to water and steam, C. Wye Williams, 29, 82
  History of St. Mary's abbey, Melrose, &c. Wade, 372
  Horse railways for branch lines, &c., Burn, 81
  Iron, its history, &c. Fairbairn, 177
  Mills and mill-work, Fairbairn, 274, 341
  Niagara railway suspension bridge, Barlow, 53
  Niagara railway suspension bridge, condition of, Roebling, 118
  Notes on screw propulsion, Walker, 121
  Office and cabin companion, Holland, 373
  Perpetuum mobile, Dircks, 245
  Practical treatise on coal, petroleum, &c., Gesner, 180
  Progressive screw as a propeller in navigation, Rêvy, 85
  Railway communication in London, and Thames embankment, Lane, 118
  Recollections of A. W. Pugin, Ferrey, 310
  Rudimentary and practical instructions on railway construction, Weale, 177
  Screw propulsion, Walker, 245
  Ship building and steam ships, theory and practice of, Murray, 243
  Steam-engine in its application to mines, mills, &c., Bourne, 243
  Strains on structures of ironwork, Shields, 119

—— Foreign Publications—
  Cathedrale de Bayeux, 218
  Der stil, &c., 247
  Die altchristclichen kirschen, 246
  Die mittelaterlicken kunstdenkmale Dalmatiens, 349
  Dictionnaire de l'académie des beaux arts, 350
  Encyclopedie d'architecture, 286
  Il giornale del ingegnere, architetto, ed agronomo, 350
  L'architecture civile et domestique, 92
  Monographie de la cathedrale de Chartres, 92, 148
  Nouvelles annales de la construction, 149, 218, 250, 285
  Rêvue générale, 279, 350

Revival of styles, Petit on, 198, 227
Rêvy on the progressive screw as a propeller in navigation (rev.) 85
Rhine, railway bridge over, 122
Ribs, tension, 79
Ringmore church, ancient remains in, 90
River Wandle, rise and fall of, Braithwaite on, 107
Robertson on large blasts at Holyhead, 38, 75
Robertson on reclamation embankment for dry dock, Leith, 162
Robinson on the application of workshop tools to construction of steam engines and other machinery, 300
Roebling on Niagara railway bridge (rev.) 118
Roman remains, 186
Romanesque art, Waring on, 114, 139
Royal academy, architecture at, 155, 211
Royal institute of British architects, 88, 161, 186, 355

S.

Saltburn-by-the-sea, hotel, 32
Sanges on new system of arranging chimneys, 218
Savoy, London, chapel royal, 154
Scarborough, church, St. Martin-on-the-hill, 347
Screw, the progressive, as a propeller in navigation, Rêvy, (rev.) 85
Screw propulsion, notes on, Walker (rev.) 121, 245
Sculpture, monumental, architectural accessories of, Cockerell on, 333
Seddon on dark ages of architecture, 259
Sewell's design for Thames embankment, 191
Shield's design for Thames embankment, 192
—— on iron construction, 296
—— on strains on structures of ironwork (rev.) 119
Ship, Queen Victoria, floating of, 90
Ships, resistance of, Rankine on, 294
—— and steam-ships, building of, Murray (rev.) 243
Sich's design for Thames embankment, 189
Siemens on the bathometer, 329
—— on electric resistance thermometer, 332
—— on railway and fire alarms, 308
Silver on ebonite, or hard India rubber, 336
Skew-bevel gearing, Rankine on, 322
Slip, the new graving, Cronstadt, 32
Smith on acoustics of public buildings (rev.) 241
—— on acoustics, 2, 46
Smirke on colour as applied to architecture, 65, 98
—— on consistency in architecture, 103
—— on consistency in style of design, 131

Societies—
  Antiquaries, 376
  Archæological association, 90
  Archæological institute, 250
  Architects, British, royal institute, 88, 161, 186, 355
  Architectural association, 368
  Architectural publication, 226
  Arts, society of, 127, 376
  British artists, society of, 148
  British association, 186, 250, 286, 327
  Encouragement of fine arts, 376
  Engineers, institution of civil, 25—annual meeting, 25, 107, 141, 171, 202—premiums 247, 373
  Engineers, mechanical, 264
  Female artists, 88
  Photographic, 69

South Kensington, proposed music hall at, 354
Southport pier, Hooper on, 113
Speed, high, on railways, 350
Spence on patent tribunals, 297
Stanford's design for Thames embankment, 190
Statics of bridges, 1, 59, 163, 223, 317, 347
Statistics of French railways, 153
Statues, colour on, Bell, 168
Statues, colour round, Bell on, 205
Statue to late Sir C. Barry, 282
Steam, density of, at different temperatures, 210
—— fire extinguished by, 141
—— in relation to boiler explosions, 138
—— power on common roads, Young (rev.) 86
—— pressure of, on cylinder covers and other disks, Byrne on, 358
—— boiler explosions, association for prevention of, 218
—— engine, Bourne on (rev.) 243
—— engines, application of workshop tools to construction of, Robinson on, 300
—— hammer, Peacock on, 240
—— Lawrie on the treatment of, for development of power, 20
—— ships, freight of, Atherton on, 304
—— ships, and ship building, Murray on (rev.) 243
Steamers, lighting, with gas, 122
Steel bridges, cast, 96
Steel, manufacture of, Bessemer on, 267
—— railway axles, 281
Stone, decay of, at new palace at Westminster, report of committee on, 337
—— and fresco painting, the preservation of, 40
—— of houses of parliament, 122
—— preservation of, 36, 65
Stoney on construction of floating beacons, 113, 146
Stoughton church, Leicestershire, restoration of, 282
Strains, shearing, of deflected girders, Cox on, 249, 279
—— on structures of ironwork, Shields (rev.) 119
Street on the restoration of ancient buildings, 199
Street railway, Westminster, 154
Strength of beam, Cooper on, 153
Structures of ironwork, strains on, Shields (rev.) 119
St. Alban's abbey, restorations, 256
St. Andrew's church, Leicester, 282
St. John's church, Chester, 154
St. John's church, Howsham, 70
St. Martin-on-the-hill, church of, Scarborough, 347
St. Mary's abbey, Melrose, &c., Wade, (rev.) 372
St. Paul's church, Hoddlesden, 226
St. Peter's church, Higham, 232
St. Peter and St. Paul's church, Cork, 30
St. Philip and St. James's church Oxford, 281
Students, architectural, proposed examinations for, 362
Study book of mediæval architecture, King (rev.) 149
Styles, revival of, Petit on, 195, 227
Submarine cable, Hall and Wells, 8
—— cables, Preece on, 25, 141
—— telegraphs, 192
Subway, Covent Garden, approach, 130
Suez canal, 101
—— discoveries at, 346
Superheated steam, 210
Suspended girder bridges, Rankine on, 4

INDEX.

Suspension bridge, Niagara railway, Barlow on (rev.) 53
—— bridge, Niagara railway, Roebling on, (rev.) 118
—— bridge, rigid, construction of, Köpcke on, 6
—— bridges, deflection of, Cox on, 207
—— girder bridges, 35
—— girder bridges, Latham on, 126
Swift's engineers' manual of the hydrometer (rev.) 176

T.

Telegraphic cables, india rubber and gutta percha, 186
Telegraphs, submarine, 192
Telluric currents, 232
Tension ribs, 79
Thames embankment, 122, 152, 187, 220

THAMES EMBANKMENT, DESIGNS FOR—
  Bardwell's, 190
  Basalgette's, 186
  Bidder, Harrison, and Stephenson, 189
  Bird's, 192
  Coombs', 190
  Doull's, 190
  Fowler, Fulton, and Hemans', 189

Thames embankment designs (continued)—
  Haggett's, 192
  Moorsom's, 191
  Newton's, 191
  Page's, 187
  Rendel's, 189
  Sewell's, 191
  Shields', 192
  Sich's, 189
  Stanford's, 190
  Thompson's, 191
  Turner's, 192
  Vetch's, 192
  Weller's, 191
  Report of commissioners, 220
Thames embankment and railway communication in London, Lane on (rev.) 118
Thermo-dynamics of elastic fluids, Gill (rev.) 55
Thermometer, electric resistance, Seimens on, 332
Thompson on the gauging of water, 360
Thul ghaut incline, 135
Timber, preservation of, 232
Tools, workshop, application of, 300
Town-hall, Kingston-upon-Hull, 122
Tribunals, patent, Spence on, 297
Tunnelling machine, 346
Turner's design for Thames embankment 192

U.

United States patent law, 184

V.

Vaughan library at Harrow, 250
Ventilation of dwellings and hospitals, 219, 324
Vetch's design for Thames embankment, 192

W.

Wade on Melrose Abbey (rev.) 372
Waggons, railway, coupling for, Markham on, 198
Walcott on church and conventual arrangement, 22
—— (rev.) 271
Walker on screw propulsion (rev.) 121, 245
Wall paintings, 376
Wandle river, Braithwaite on rise and fall of, 107
Waring on romanesque art, 114, 189
Warming of buildings, 184
Warming of railway carriages, 90
Water supply of London, Burnell on, 71
Water, gauging of, Thompson on, 360
Watches, clocks, and bells, Denison on, 342
Weale, works issued by, 375
Webster, on property in inventions, 331
Wellingborough church, restoration of, 376
Wellington college, 251
Westminster palace, report on decay of stone, 337
Whitehall, India museum, [illegible]
Wiesbach's formula for finding the head due to the friction of water in pipes, 375
Williams, C. Wye, on heat in its relation to water and steam (rev.) 29, 82
Wooden fences, preservation of, 90
Worcester cathedral, restoration of, 280
Working mens' dwellings, Leeds, 154
Works on fine and constructive arts, Weale 375
Workshop tools applied to construction of machinery, Robinson on, 300
Worms, Luther's monument at, 90

Y.

York, Lendal bridge, 155
York minster, 270
Young on economy of steam power on common roads (rev.) 36

PLATE ENGRAVINGS.

Plate		Opposite page
1.	—Lichfield Cathedral; Interior View	1
2.	—Plans of the Episcopal Palace, Ely Place, London, in 1772	5
3.	—St. Etheldreda's Chapel, Ely Place, London: South-west Doorway	6
4.	—Cochrane's Apparatus for taking off the Waste Gases from Blast Furnaces	15
5.	—St. Etheldreda's Chapel, Ely Place, London: Interior Elevation and Details of South-west Doorway	33
6.	—St. Etheldreda's Chapel, Ely Place, London: East Window	34
7.	—House at Mayfield, Sussex; and part Plan	53
8.	—Ditto, various details	
9.	—Church of St. John the Evangelist, Howsham, Yorkshire: Exterior View and Plan	70
10.	—St. Etheldreda's Chapel, Ely Place, London: Longitudinal Section, looking South	
11.	—Details of Dock Improvements at Grangemouth	86
12.	International Exhibition Building of 1862: South Elevation Ground Plan of ditto	99
13.	—Church of St. John the Evangelist, Howsham, Yorkshire: Interior View	
14 and 15.	—Subway for Water and Gas Mains, &c., New Approach, Govent Garden, London: Plans amd Sections	130
16.	New Church, Ince-in-Mackerfield, Lancashire Outwell Church, Norfolk, South-east View, Restored	150
17.	—Lendal Iron Girder Bridge, York: Elevation and Plan	155
18.	—Lendal Iron Girder Bridge, York: Details of large Road Girders, &c.	155
19.	—New Independent Chapel, Abergele, North Wales: Perspective View and Plan	166
20 & 21.	—Embankment of the Thames: Sections and Plans of various Designs	187
22.	—St. Etheldreda's Chapel, Ely Place, London: West Window, with Details	
23.	—New Chapel, Hampstead, Middlesex	219
24.	—St. Paul's Church, Hoddlesden, Lancashire	226
25.	—Steam Hammer for Light Forgings	240
26.	—Llandaff Cathedral: View of West Front, as restored	251
27.	—New Bridge across the Thames, at Lambeth: Part Elevation, Plan, and Section	283
28.	—New Bridge across the Thames, at Lambeth: Part Elevation and Details	283
29.	—Ashwicke Hall, Gloucestershire	315
30.	—Ditto: Ground Plan and Chamber Plan	315
31.	—Diagram, showing Ratio of Breaking Weight and Span of Tubular Girder Bridges, according to the Formulæ of the Board of Trade and William Fairbairn, C.E.	328
32.	—Church of St. Martin-on-the-hill, Scarborough	347

W. KNOTT, PRINTER, GREVILLE STREET, HATTON GARDEN, E.C.

NOV 10 1952